

Steam System Modeling Tool

Overview and Tour



U.S. DEPARTMENT OF
ENERGY

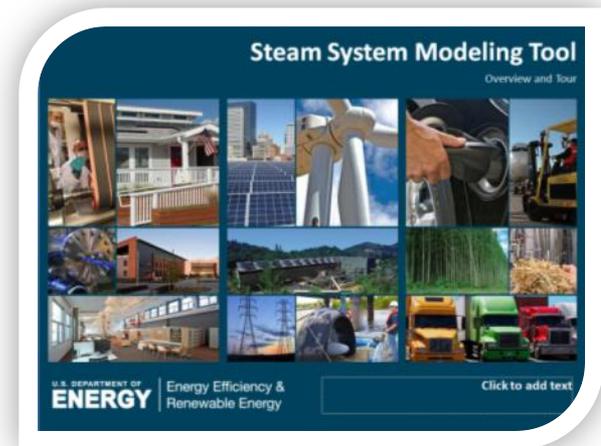
Energy Efficiency &
Renewable Energy

How to use this Document

This document is designed to be used as both a comprehensive presentation and a quick reference for the **Steam System Modeling Tool (SSMT)**

To use as a quick reference:

- The [table of contents](#) provides links to all of the key topics covered.
- Each page also includes a direct link back to the table of contents
- A direct link to SSMT is also provided at the bottom of every page ↓ (*internet connection required*)



[GO TO SSMT ONLINE](#)

How to use SSMT

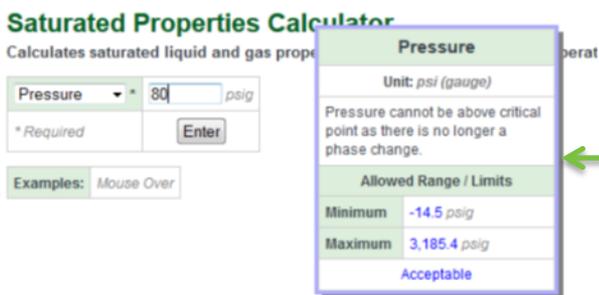
SSMT is designed to be easy to use with significant built-in documentation and detailed calculations. Specifically the examples, and pop-up hints allows users to test all features instantly and get immediate feedback:

Examples are available in all calculators and the modeler. When selected, they demonstrate the functions of the calculators by being loaded just as though it had been entered by the user. Almost all examples are randomly generated, allowing users to evaluate numerous examples.

Pop-Up Hints appear for all data fields

Every data field has a pop-up hint that provides details about the field units, description, acceptable range, and where the entered value is valid.

Examples →



Pop-Up Hints

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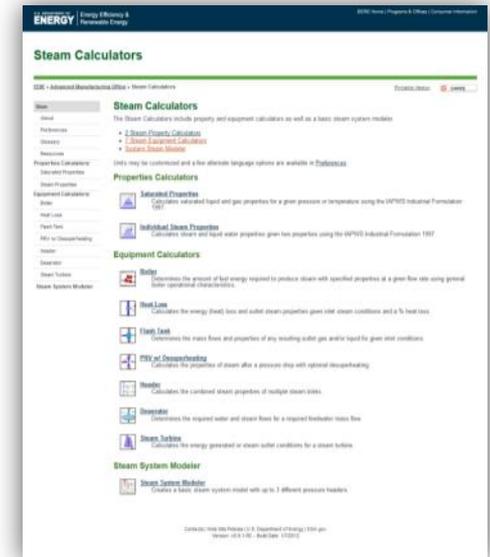
[Steam Properties](#) and [Calculators](#)

Equipment Calculators [[description structure](#)]:

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- **Heat Loss:** [Overview](#) [Inputs](#) [Calculation](#) [Results](#)
- **Flash Tank:** [Overview](#) [Inputs](#) [Calculation](#) [Results](#)
- **PRV:** [Overview](#) [Inputs](#) [Calculation](#) [Results](#)
- **Header:** [Overview](#) [Inputs](#) [Calculation](#) [Results](#)
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Steam System Modeler:

-SEE FOLLOWING PAGE



Main Entry Page of SSMT

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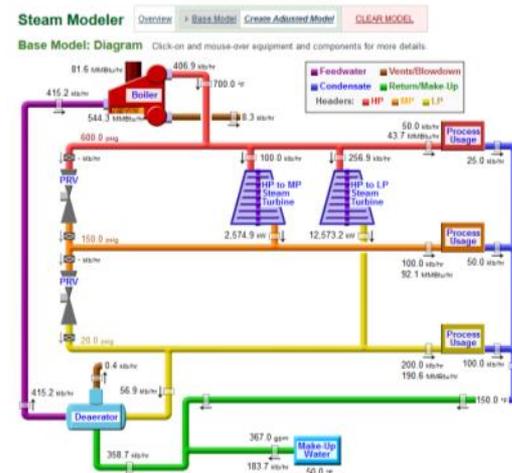
[Tips and Tricks](#)

Introduction (1/2)

The **Steam System Modeling Tool (SSMT)** is designed to enable steam system operators to both better understand their systems and provide the tools to evaluate potential improvements.

Key features include:

- **Custom Steam Property Tables**
- **Equipment Calculators**
- **Steam System Modeler**
- **Web-based**
- **Customizable Units**
- **Transparent Calculations**



Introduction (2/2) - Key Feature Details

Custom Steam Property Tables

Users can generate customized steam tables based on specific operating conditions of their steam system.

Equipment Calculators

Basic steam system equipment can be independently modeled and evaluated without creating a complete model.

Steam System Modeler

A 1-3 header steam system model can be generated with the associated PRVs, steam turbines, flash tanks, heat losses, and condensate return conditions. Users can then evaluate the impact of a significant number of adjustments to the model.

Web-based

Only an internet connection and the current version of any major browser are required to immediately start using SSMT. *There are no installation requirements.*

Customizable Units

Users can select and switch between a number of different units at any time.

Transparent Calculations

Calculations details are provided through tool to allow users to verify results.

General Layout and Structure

Major Sections of SSMT:

- General Information
- Property Calculators
- Equipment Calculators
- Steam System Modeler

All calculators follow a similar format *detailed on the following page.*

Main	Properties Calculators
About	 Saturated Properties Calculates saturated liquid and gas properties for a given pressure.
Preferences	 Individual Steam Properties Calculates steam and liquid water properties given two properties.
Glossary	Equipment Calculators
Resources	 Boiler Determines the amount of fuel energy required to produce steam at a given boiler operational characteristics.
Properties Calculators:	 Heat Loss Calculates the energy (heat) loss and outlet steam properties for a given boiler.
Saturated Properties	 Flash Tank Determines the mass flows and properties of any resulting steam and water from a flash tank.
Steam Properties	 PRV w/ Desuperheating Calculates the properties of steam after a pressure drop through a PRV with desuperheating.
Equipment Calculators:	 Header Calculates the combined steam properties of multiple headers.
Boiler	 Deaerator Determines the required water and steam flows for a deaerator.
Heat Loss	 Steam Turbine Calculates the energy generated or steam outlet conditions for a steam turbine.
Flash Tank	Steam System Modeler
PRV w/ Desuperheating	 Steam System Modeler Creates a basic steam system model with up to 3 different components.
Header	
Deaerator	
Steam Turbine	
Steam System Modeler	

General Calculator Layout

The screenshot shows the 'Heat Loss Calculator' interface. It includes a sidebar with navigation options, a main input area for 'Inlet' properties (Pressure, Temperature, Mass Flow, Percent Heat Loss), a central diagram of a steam pipe with heat loss, and a detailed 'Calculation Details' section. Annotations with blue arrows point to various parts of the interface:

- Data Inputs with pop-up tips and data validation:** Points to the input fields for Pressure, Temperature, Mass Flow, and Percent Heat Loss.
- Diagram of Equipment with Complete Steam Property Details:** Points to the central diagram showing a vertical pipe with heat loss, and the 'Inlet Steam' and 'Outlet Steam' property tables.
- Examples for a few common configurations with random data:** Points to the 'Examples' section under the 'Example Liquid' heading.
- Assumptions specific to the calculation:** Points to the 'Assumptions' section at the bottom of the calculation details.
- Calculation Details populated with data from current calculation:** Points to the 'Calculation Details' section, which shows step-by-step calculations for inlet and outlet properties.

Diagram of Equipment with Complete Steam Property Details

Calculation Details populated with data from current calculation

Data Inputs with pop-up tips and data validation

Examples for a few common configurations with random data

Assumptions specific to the calculation

Customizing Units and Language

The **Preferences** page allows users to customize the following at anytime:

- Unit Types
- Language
- Currency Symbol

By default, NO information will be stored about the users preferences. If a user wishes to store their preferences between sessions they must switch the “Permanently Store Preferences” Option to “Yes”

Permanently Store Preferences
No ▾

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Steam Calculators

EEER > Advanced Manufacturing Office > Steam Calculators > Preferences

Main

- About
- Preferences**
- Glossary
- Resources

Properties Calculators:

- Saturated Properties
- Steam Properties

Equipment Calculators:

- Boiler
- Heat Loss
- Flash Tank
- PRV w/ Desuperheating
- Header
- Deaerator
- Steam Turbine
- Steam System Modeler

Preferences
Set preferred unit systems, individual units, and languages.

Language: English ▾

Currency Symbol: \$ ▾

Measurement System: Custom ▾ *Select 'Custom' to pick individual units

	Imperial	SI	Chinese	Custom
Temperature	°F	°C	°C	Fahrenheit °F ▾
Pressure	psig	barg	barg	psi (gauge) ▾
Vacuum Pressure	psia	bara	bara	psi (absolute) ▾
Specific Enthalpy	btu/lbm	kJ/kg	kJ/kg	btu/lbm ▾
Specific Entropy	btu/lbm/R	kJ/kgK	kJ/kgK	btu/lbm/R ▾
Specific Volume	ft ³ /lb	m ³ /kg	m ³ /kg	ft ³ /lb ▾
Mass Flow	lb/hr	t/hr	t/hr	lb/hr ▾
Density	lb/ft ³	g/m ³	g/m ³	lb/ft ³ ▾
Energy Flow	MMBtu/hr	KW	TCE/hr	MMBtu/hr ▾
Energy	MMBtu	Nm ³	TCE	MMBtu ▾
Power	kW	kW	kW	kW ▾
Electricity	kWh	kWh	kWh	kWh ▾
Volume	gal	l	l	gal ▾
Volume Flow	gpm	lpm	lpm	gpm ▾

Permanently Store Preferences: No ▾

[UPDATE PREFERENCES](#)

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Customizing Units

- Users may select between predefined units sets or customize each individual unit.
- This may be done at **any time**, even if a model has already been generated. The model and entered values will all be updated to match the new units.
- SSMT remembers which units were selected when any values are entered. This ensures that entered values are at most converted only 1 time regardless of how many times a user switches units.

The screenshot shows the 'Preferences' window for the 'Steam Calculators' tool. The 'Measurement System' is set to 'Custom'. A table below the screenshot lists the available units for various properties.

	Imperial	SI	Chinese	Custom
Temperature	°F	°C	°C	Fahrenheit °F
Pressure	psig	barg	barg	psi (gauge)
Vacuum Pressure	psia	bara	bara	psi (absolute)
Specific Enthalpy	btu/lbm	kJ/kg	kJ/kg	btu/lbm
Specific Entropy	btu/lbm/R	KJ/kg/K	KJ/kg/K	btu/lbm/R
Specific Volume	ft³/lb	m³/kg	m³/kg	ft³/lb
Mass Flow	klb/hr	t/hr	t/hr	klb/hr
Density	lb/ft³	g/m³	g/m³	lb/ft³
Energy Flow	MMBtu/hr	kW	TCE/hr	MMBtu/hr
Energy	MMBtu	Nm³	TCE	MMBtu
Power	kW	kW	kW	kW
Electricity	kWh	kWh	kWh	kWh
Volume	gal	l	l	gal
Volume Flow	gpm	lpm	lpm	gpm

Customizing Languages

- SSMT is design to support alternate languages options. It currently includes:
 - Chinese
 - Russian
- To further support international use of the tool, users can also select an alternate currency symbol.
 - This is used in the steam system modeler which includes steam related costs and cost savings calculated from various system adjustments.

The screenshot displays the 'Preferences' section of the 'Steam Calculators' tool. The interface is in Chinese. The 'Language' dropdown is set to '中文'. The 'Currency Symbol' is set to '\$'. A table of unit conversions is shown, comparing SI units to Chinese units. A success message '偏好更新成功' is visible, indicating the settings have been saved.

SI	中国
温度	°F °C °C
压力	psig barg barg
真空压力	psia bara bara
比焓	kJ/kg kJ/kg
比熵	kJ/kgK kJ/kgK
比容	m³/kg m³/kg
质量流量	kg/hr kg/hr
密度	kg/m³ g/m³
质量流	kg/hr TCE/hr
质量	kg TCE
电力	kW kW
功率	kWh kWh
容量	gal l
容量流量	gpm lpm

Steam Properties

SSMT calculates *all* steam properties using the *International Association for the Properties of Water and Steam's Thermodynamic Properties of Water and Steam Industrial Formulation, IAPWS-IF97, 2007*, www.iapws.org

Calculated properties include:*

- Pressure
- Temperature
- Specific Enthalpy
- Specific Entropy
- Phase
- Quality
- Specific Volume

**Due to the complexity of the steam calculations, they are not displayed by SSMT.*



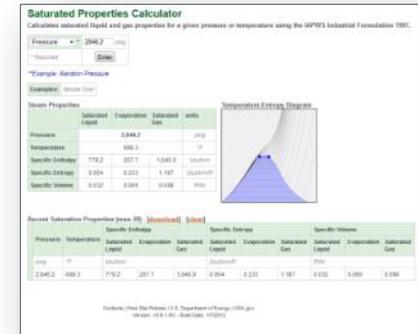
SSMT Steam Property Calculators

SSMT provides 2 steam property calculators:

- Saturated Properties Calculator
 - Determines saturated liquid and gas properties for a given pressure or temperature
- Steam Properties Calculator
 - Determines steam and liquid water properties given two properties that fix the state

Both calculators include:

- Steam Property Details
- Temperature-Entropy Diagram (Vapor Dome)
- History of 20 most recent property calculation
- Downloadable properties (*custom steam tables*)



Saturated Properties Calculator

Saturated Properties Calculator

Determines saturated liquid and gas properties for a given pressure or temperature

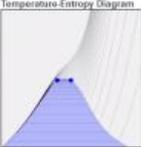
- Saturated liquid and gas refer to the 2 separate states of water that co-exist when boiling
- Both the saturated liquid and the gas will be the same temperature and pressure
- Quality refers to the portion of the total mass of water that is a gas/vapor (0 to 1). A quality of 1 indicates that it is entirely a saturated gas/vapor
- Saturated properties can be determined given only the temperature or pressure as they both correspond to the boiling temperature at a given pressure

Saturated Properties Calculator
Calculates saturated liquid and gas properties for a given pressure or temperature using the IAPWS Industrial Formulation 1997.

Pressure:
* Required

**Example: Random Pressure
Examples:

Steam Properties	Saturated Liquid	Evaporation	Saturated Gas	units
Pressure	2,046.2			pmp
Temperature	680.3			°F
Specific Enthalpy	779.2	267.7	1,048.9	Btu/lbm
Specific Entropy	0.954	0.233	1.187	0.001Btu/lbmR
Specific Volume	0.032	0.066	0.098	ft ³ /lb



Recent Saturation Properties (max 20)

Pressure	Temperature	Specific Enthalpy		Specific Entropy		Specific Volume				
		Saturated Liquid	Evaporation	Saturated Liquid	Evaporation	Saturated Liquid	Evaporation			
pmp	°F	Btu/lbm		Btu/lbmR		ft ³ /lb				
2,046.2	680.3	779.2	267.7	1,048.9	0.954	0.233	1.187	0.032	0.066	0.098

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Steam Properties Calculator

Steam Properties Calculator

Determines steam and liquid water properties given two properties that fix the state

- Pressure and a secondary steam property are required to determine the exact state of the steam
- Potential secondary properties include:
 - Temperature
 - Specific Enthalpy
 - Specific Entropy
 - Quality
- This calculator can evaluate: sub-cooled liquid, saturated liquid, saturated mixture, saturated gas, superheated gas, and supercritical properties

Individual Steam Properties Calculator
Calculates steam and liquid water properties given two properties using the IAPWS Industrial Formulation for the Equation of State (IAPWS-IF97).

Pressure* 666 psig
Saturated Quality 0.23
* Required Enter

Example: Saturated Mixture
Examples: Mouse Over

Steam Properties	Units
Pressure	666.0 psig
Temperature	500.0 °F
Specific Enthalpy	652.2 Btu/lbm
Specific Entropy	0.860 Btu/lbm-R
Phase / Quality	0.23
Specific Volume	0.171 ft ³ /lb

Temperature-Entropy Diagram

Recent Properties (max 20) - [download] - [clear]

Pressure	Temperature	Specific Enthalpy	Specific Entropy	Phase / Quality	Specific Volume
psig	°F	Btu/lbm	Btu/lbm-R		ft ³ /lb
666.0	500.0	652.2	0.860	0.23	0.171
1,066.0	553.0	941.5	1.137	0.61	0.261

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SSMT Equipment Calculators:

Boiler Calculator

Heat Loss Calculator

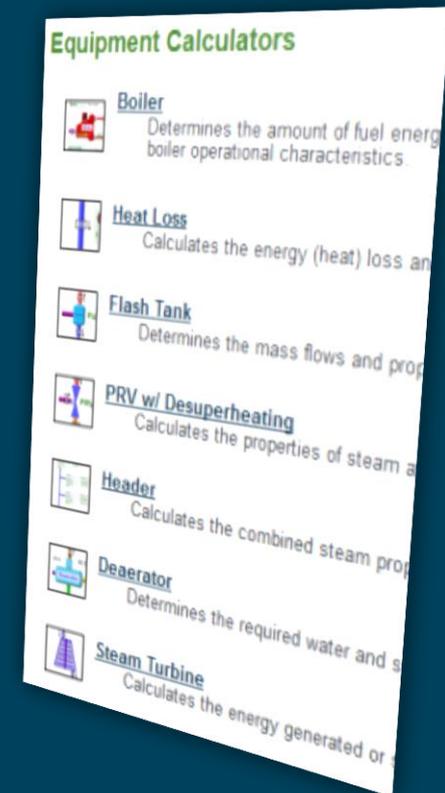
Flash Tank Calculator

PRV w/ Desuperheating Calculator

Header Calculator

Deaerator Calculator

Steam Turbine Calculator



OVERVIEW

Description of the calculator and key features

INPUTS

Each input listed in the following format:

INPUT NAME [**property type**]:
description of input type

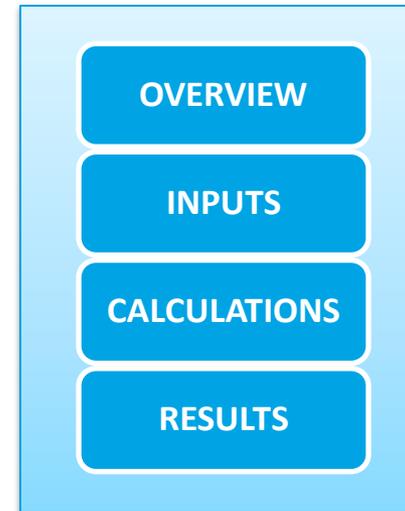
CALCULATIONS

Each step listed in the following format:

Step #: Description
additional details

RESULTS

Listing of all calculations results provided by the calculator



The **Boiler Calculator** determines the amount of fuel energy required to produce steam with the specified properties at a given flow rate using general boiler operational characteristics.

Capable of evaluating generation of:

- Saturated Steam
- Superheated Steam
- Supercritical Steam

Boiler Calculator
Determines the amount of fuel energy required to produce steam with specified properties at a given flow rate using general boiler operational characteristics.

Parameter	Value	Units
Deaerator Pressure*	35.2	psig
Combustion Efficiency*	79.9	%
Blowdown Rate*	3.7	%

Parameter	Value	Units
Pressure*	853.4	psig
Saturated Quality *	1	
Steam Mass Flow *	85.1	klb/hr

Parameter	Value	Units
Mass Flow	85.1	klb/hr
Sp. Enthalpy	1,197.2	btu/lbm
Temperature	527.8	°F
Sp. Entropy	1.407	btu/lbm-R
Saturated	1.00	
Energy Flow	101.9	MMBtu/hr

Parameter	Value	Units
Blowdown Rate	3.7	%
Blowdown Energy	81.5	MMBtu/hr
Combustion Efficiency	79.9	%
Fuel Energy	102.0	MMBtu/hr

Parameter	Value	Units
Mass Flow	3.3	klb/hr
Sp. Enthalpy	521.5	btu/lbm
Temperature	527.8	°F
Sp. Entropy	0.723	btu/lbm-R
Saturated	0.00	
Energy Flow	1.7	MMBtu/hr

Parameter	Value	Units
Mass Flow	88.4	klb/hr
Sp. Enthalpy	250.1	btu/lbm
Temperature	280.9	°F
Sp. Entropy	0.411	btu/lbm-R
Saturated	0.00	
Energy Flow	22.1	MMBtu/hr

Calculation Details

Step 1: Determine Properties of Steam Produced
Using the Steam Property Calculator, properties are determined using Steam Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality). The Specific Enthalpy is then multiplied by the Mass Flow to get the Energy Flow.

- Pressure = 853.4 psig
- Quality = 1.00
- [Steam Property Calculator] => specific enthalpy = 1,197.2 btu/lbm
- Steam Energy Flow = Specific Enthalpy * Mass Flow
[Steam Energy Flow = 101.9 MMBtu/hr = 1,197.2 btu/lbm * 85.1 klb/hr]

Step 2: Determine Feedwater Properties and Mass Flow
The feedwater flow rate can be calculated from steam mass flow and blowdown rate:

1. Blowdown Mass Flow = Feedwater Mass Flow * Blowdown Rate
2. Steam Mass Flow = Feedwater Mass Flow - Blowdown Mass Flow
3. Steam Mass Flow = Feedwater Mass Flow - Feedwater Mass Flow * Blowdown Rate
4. Feedwater Mass Flow = Steam Mass Flow / [1 - Blowdown Rate]
[Feedwater Mass Flow = 88.4 klb/hr = 85.1 klb/hr / (1 - 0.037)]

Using the Steam Property Calculator, properties are determined using Deaerator Pressure and Quality = 0 (Saturated Liquid). The Specific Enthalpy is then multiplied by the Mass Flow to get the Energy Flow.

- Pressure = 35.2 psig
- Quality = 0.00
- [Steam Property Calculator] => specific enthalpy = 250.1 btu/lbm
- Feedwater Energy Flow = Specific Enthalpy * Mass Flow
[Feedwater Energy Flow = 22.1 MMBtu/hr = 250.1 btu/lbm * 88.4 klb/hr]

Step 3: Determine Blowdown Properties and Mass Flow
Using the calculated feedwater mass flow and blowdown rate:

- Blowdown Mass Flow = Feedwater Mass Flow * Blowdown Rate
[Blowdown Mass Flow = 3.3 klb/hr = 88.4 klb/hr * 0.037]

Deaerator Pressure [pressure]:

Initial pressure of the feedwater before it is increased to boiler pressure

Combustion Efficiency [%]:

% of the fuel energy that is transferred to the boiler water and steam

Blowdown Rate [%]:

% of feedwater being drained from the boiler as a saturated liquid to reduce the concentration of dissolved solids

Pressure [pressure]:

Operating pressure of the boiler, blowdown, and generated steam

Secondary Steam Property [*varies*]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the generated steam

Steam Mass Flow [mass flow]:

Mass flow of the steam produced by the boiler

Boiler Calculator

Determines the amount of fuel energy required to boiler operational characteristics.

Deaerator Pressure*	<input type="text" value="35.2"/> <i>psig</i>
Combustion Efficiency*	<input type="text" value="79.9"/> %
Blowdown Rate*	<input type="text" value="3.7"/> %
Steam	
Pressure*	<input type="text" value="853.4"/> <i>psig</i>
Saturated Quality ▾ *	<input type="text" value="1"/>
Steam Mass Flow *	<input type="text" value="85.1"/> <i>kib/hr</i>
* Required	<input type="button" value="Enter"/> <input type="button" value="reset"/>

Step 1: Determine Properties of Steam Produced

Steam properties are determined using the **Pressure**, **Secondary Steam Property**, and **Steam Mass Flow**.

Step 2: Determine Feedwater Properties and Mass Flow

Feedwater properties are assumed to be equal to the properties of saturated liquid at **Deaerator Pressure**. The feedwater mass flow is calculated using the **Blowdown Rate** and **Steam Mass Flow**.

Step 3: Determine Blowdown Properties and Mass Flow

The blowdown properties are assumed to be equal to the properties of a saturated liquid at Boiler **Pressure**. The blowdown mass flow is calculated using the **Blowdown Rate** and feedwater mass flow.

Step 4: Determine Boiler Energy

The boiler energy is calculated as the difference between the total outlet (steam, blowdown) energy flows and inlet (feedwater) energy flows.

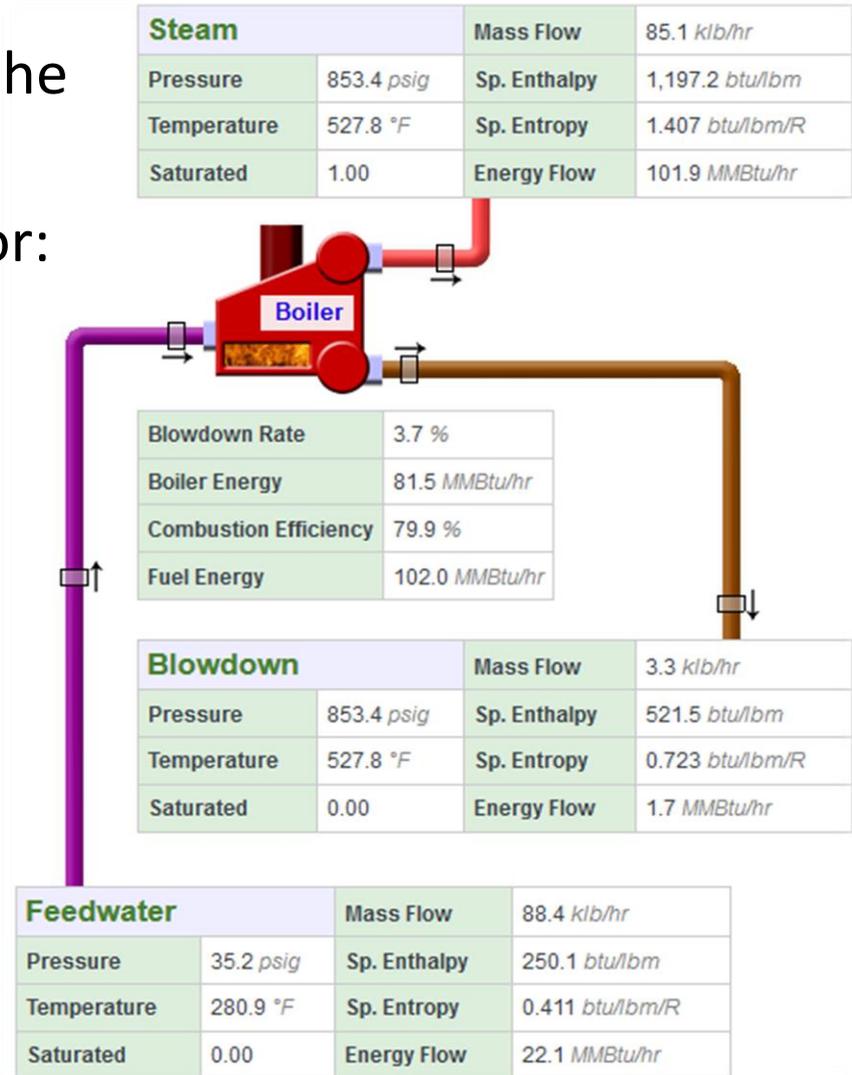
Step 5: Determine Fuel Energy

The total required fuel energy is determined by dividing the boiler energy by the **Combustion Efficiency**.



The **Boiler Calculator** provides the following results:

- Properties and Mass Flows for:
 - Feedwater
 - Blowdown
 - Generated Steam
- Boiler Energy
- Required Fuel Energy



The **Heat Loss Calculator** determines the energy [heat] loss and outlet steam properties for a steam pipe or header based on specific given inlet steam conditions and a % heat loss.

- % heat loss is relative to the triple point of water at which point the energy content of water is set a 0
- This calculator is primarily used to determine the % heat loss that best approximates the actual heat loss on a specific steam header

Heat Loss Calculator
Calculates the energy (heat) loss and outlet steam properties given inlet steam conditions and a % heat loss.

Inlet		Inlet Steam		Mass Flow	
Pressure*	929.0 psig	Pressure	929.0 psig	Sp. Enthalpy	420.4 btu/lbm
Temperature	440.9 °F	Temperature	440.9 °F	Sp. Entropy	0.615 btu/lbm-R
Mass Flow*	23.6 klb/hr	Phase	Liquid	Energy Flow	9.9 MMbtu/hr

Percent Heat Loss* 7.95 %
* Required Enter (Reset)

Example: Liquid
Example: Abuse Over

Outlet Steam		Mass Flow	
Pressure	929.0 psig	Sp. Enthalpy	387.0 btu/lbm
Temperature	410.3 °F	Sp. Entropy	0.578 btu/lbm-R
Phase	Liquid	Energy Flow	9.1 MMbtu/hr

Heat Loss 7.95 %
Heat Loss 0.8 MMbtu/hr

Calculation Details and Assumptions below

Calculation Details

Step 1: Determine Inlet Properties
Using the Steam Property Calculator, properties are determined using Inlet Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality). The Specific Enthalpy is then multiplied by the Mass Flow to get the Energy Flow

- Pressure = 929.0 psig
- Temperature = 440.9 °F
- [Steam Property Calculator](#) => Specific Enthalpy = 420.4 btu/lbm
- Inlet Energy Flow = Specific Enthalpy * Mass Flow
[Inlet Energy Flow = 9.9 MMbtu/hr = 420.4 btu/lbm * 23.6 klb/hr]

Step 2: Determine Outlet Energy Flow after Heat Loss

- Outlet Energy Flow = Inlet Energy Flow * (1 - Heat Loss (%))
[Outlet Energy Flow = 9.1 MMbtu/hr = 9.9 MMbtu/hr * (1 - 0.0795)]

Step 3: Determine Outlet Properties
The outlet specific enthalpy is determined from energy and mass flows:

1. Outlet Mass Flow = Inlet Mass Flow
2. Outlet Energy Flow = Outlet Mass Flow * Outlet Specific Enthalpy
3. Outlet Specific Enthalpy = Outlet Energy Flow / Inlet Mass Flow
[Outlet Specific Enthalpy = 387.0 btu/lbm = 9.1 MMbtu/hr / 23.6 klb/hr]

Using the Steam Property Calculator, properties are determined using Pressure and Specific Enthalpy:

- Pressure = 929.0 psig
- Specific Enthalpy = 387.0 btu/lbm
- [Steam Property Calculator](#) => Temperature = 410.3 °F

Assumptions

- Inlet Mass Flow equals Outlet Mass Flow
- Baseline (0 Energy Flow) is set at the triple point for water
- % Heat Loss is relative to the Baseline

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Pressure [pressure]:

Pressure of the input steam

Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Mass Flow [mass flow]:

Mass flow of the steam

Percent Heat Loss [%]:

% of steam heat [enthalpy] lost between the inlet and the outlet

Heat Loss Calculator
Calculates the energy (heat) loss and outlet steam

Inlet	
Pressure*	929 psig
Temperature *	440.9 °F
Mass Flow *	23.6 klb/hr
Percent Heat Loss *	7.95 %
* Required	<input type="button" value="Enter"/> <input type="button" value="reset"/>

Step 1: Determine Inlet Properties

Inlet steam properties are determined using the **Pressure**, **Secondary Steam Property**, and **Mass Flow**.

Step 2: Determine Outlet Energy Flow after Heat Loss

The outlet energy flow calculated by reducing the inlet energy flow by the **Percent Heat Loss**.

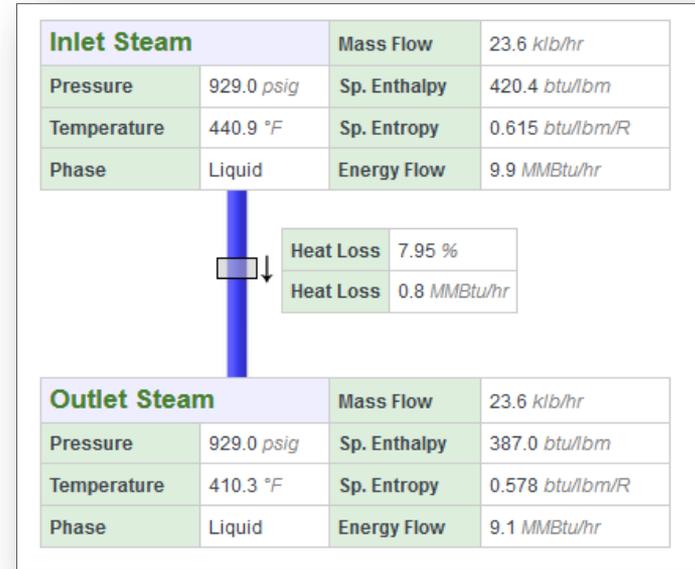
Step 3: Determine Outlet Properties

The outlet steam properties are determined using the **Inlet Pressure** and the calculated outlet energy flow.



The **Heat Loss Calculator** provides the following results:

- Inlet Steam Properties
- Outlet Steam Properties
- Total Heat Loss



The **Flash Tank Calculator** determines the mass flows and steam properties of any resulting outlet gas and/or liquid from a flash tank based on inlet conditions.

A **flash tank** is used to capture the steam generated when a high pressure, high temperature liquid has its pressure reduced causing some of the liquid to vaporize, as known as flashing.

Flash Tank Calculator

Determines the mass flows and properties of any resulting outlet gas and/or liquid for given inlet conditions.

Inlet	
Pressure*	622 psig
Saturated Quality*	0.01
Mass Flow*	47.3 lb/hr
Tank Pressure*	393.1 psig

* Required

Example: Saturated Mixture

Inlet Water		Mass Flow	
Pressure	622.0 psig	Sp. Enthalpy	486.5 Btu/lbm
Temperature	482.7 °F	Sp. Entropy	0.688 Btu/lbmR
Saturated	0.01	Energy Flow	23.0 MBtu/hr

Outlet Gas		Mass Flow	
Pressure	393.1 psig	Sp. Enthalpy	1,205.1 Btu/lbm
Temperature	448.5 °F	Sp. Entropy	1.483 Btu/lbmR
Saturated	1.00	Energy Flow	4.4 MBtu/hr

Outlet Liquid		Mass Flow	
Pressure	393.1 psig	Sp. Enthalpy	426.3 Btu/lbm
Temperature	448.5 °F	Sp. Entropy	0.824 Btu/lbmR
Saturated	0.00	Energy Flow	18.6 MBtu/hr

Calculation Details

Step 1: Determine Inlet Water Properties
 Using the Steam Property Calculator, properties are determined using Inlet Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality).

- Pressure = 622.0 psig
- Quality = 0.01
- [Steam Property Calculator]** => Inlet Specific Enthalpy = 486.5 Btu/lbm

Step 2: Determine the Specific Enthalpy and other properties for Saturated Liquid and Gas at Flash Pressure

- Pressure = 393.1 psig
- [Saturated Properties Calculator]** =>
 - Saturated Liquid Specific Enthalpy = 426.3 Btu/lbm
 - Saturated Gas Specific Enthalpy = 1,205.1 Btu/lbm

Step 3: Evaluate Flash Tank
 If Inlet Specific Enthalpy is less than the Saturated Liquid Specific Enthalpy, only liquid leaves the flash tank at inlet specific enthalpy and flash tank pressure.
 If Inlet Specific Enthalpy is greater than the Saturated Gas Specific Enthalpy, only steam leaves the flash tank at inlet specific enthalpy and flash tank pressure.
 If Inlet Specific Enthalpy is in between, proceed to Step 4.

- Proceed to Step 4.

Step 4: Determine Flash Properties
 Using an mass and energy balance equations:

- Mass Flow = MF
- Specific Enthalpy = HE
- Energy Flow = MF * HE
- Inlet Water MF = Outlet Gas MF + Outlet Liquid MF
- Inlet Water HE = Inlet Water HE = [Outlet Gas MF * Outlet Gas HE] + [Outlet Liquid MF * Outlet Liquid HE]
- Outlet Gas MF = Inlet Water MF - Outlet Liquid MF
- Inlet Water MF * Inlet Water HE = [Outlet Water MF * Outlet Liquid HE] + [Outlet Gas MF * Outlet Gas HE]
- Inlet Water MF * Inlet Water HE = [Inlet Water MF * Inlet Water HE] + [Outlet Liquid MF * Outlet Liquid HE]
- Outlet Liquid MF = Outlet Liquid MF - [Outlet Liquid MF * Outlet Gas HE] + [Inlet Water MF * Inlet Water HE] - [Inlet Water MF * Outlet Gas HE]
- Outlet Liquid MF = [Outlet Liquid MF * Outlet Gas HE] + [Inlet Water MF * Inlet Water HE] - [Inlet Water MF * Outlet Gas HE]
- Outlet Liquid MF = Inlet Water MF - Outlet Gas MF
- Outlet Liquid MF = Inlet Water MF - Outlet Gas MF
- Outlet Gas MF = Inlet Water MF - Outlet Liquid MF
- Outlet Gas MF = Inlet Water MF - Outlet Liquid MF

Assumptions

- Total Inlet and Outlet Mass flows are equal. No mass is lost or gained.
- Total Inlet and Outlet Energy flows are equal. No energy is lost or gained.

Pressure [pressure]:

Pressure of the input steam

Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Mass Flow [mass flow]:

Mass flow of the steam

Percent Heat Loss [pressure]:

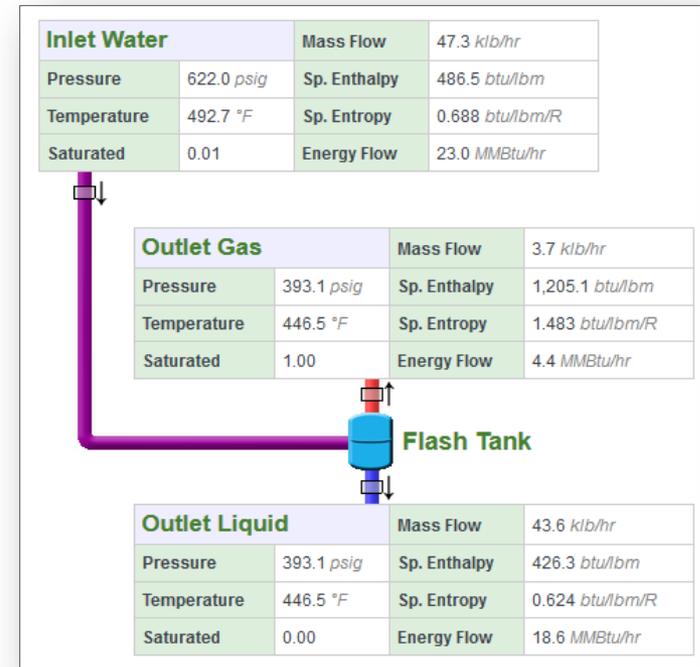
Pressure inlet steam is reduced to in the flash tank

Flash Tank Calculator
Determines the mass flows and properties of an

Inlet	
Pressure*	622 <small>psig</small>
Saturated Quality ▾ *	0.01
Mass Flow *	47.3 <small>klb/hr</small>
Tank Pressure *	393.1 <small>psig</small>
* Required	<input type="button" value="Enter"/> <input type="button" value="reset"/>

The **Flash Tank Calculator** provides the following results:

- Properties and Mass Flows for:
 - Inlet High Pressure Water
 - Outlet Gas
 - Outlet Liquid



The **Pressure Reducing Valve (PRV) Calculator** determines the properties of steam after a pressure drop with optional desuperheating.

PRVs reduce the pressure of steam without adding or removing energy. This is known as an isenthalpic process.

In some cases, outlet steam needs to be reduced to a set temperature. To do this, PRVs can be configured to desuperheat the outlet steam by injecting water into the steam.

PRV w/ Desuperheating Calculator
Calculates the properties of steam after a pressure drop with optional desuperheating.

Inlet		Mass Flow	
Pressure*	226 psig	Mass Flow	60.3 klb/hr
Temperature	554.4 °F	Sp. Enthalpy	1,294.8 btu/lbm
Mass Flow*	60.3 klb/hr	Temperature	554.4 °F
		Sp. Entropy	1.631 btu/lbmR
		Phase	Gas
		Energy Flow	78.1 MBtu/hr

Outlet

Outlet		Mass Flow	
Pressure	156.6 psig	Mass Flow	63.3 klb/hr
Temperature	455.0 °F	Sp. Enthalpy	1,247.6 btu/lbm
Phase	Gas	Sp. Entropy	1.618 btu/lbmR
		Energy Flow	79.0 MBtu/hr

Feedwater

Feedwater		Mass Flow	
Pressure*	79.1 psig	Mass Flow	3.0 klb/hr
Saturated Quality	0	Pressure	79.1 psig
Desuperheating Temperature*	455 °F	Sp. Enthalpy	293.8 btu/lbm
		Temperature	323.2 °F
		Sp. Entropy	0.488 btu/lbmR
		Saturated	0.00
		Energy Flow	0.9 MBtu/hr

Calculation Details and Assumptions below

Calculation Details

Step 1: Determine Inlet Steam Properties
Using the Steam Property Calculator, properties are determined using Inlet Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality).

- Pressure = 226.0 psig
- Temperature = 554.4 °F
- [Steam Property Calculator] => Specific Enthalpy = 1,294.8 btu/lbm

Step 2: If NO Desuperheating: Determine Outlet Steam Properties
A PRV is an isenthalpic process, meaning the inlet enthalpy is equal to the outlet enthalpy. The outlet properties are determined using the inlet enthalpy and outlet pressure.

Step 2: If Desuperheating: Determine Cooling Water Properties
Using the Steam Property Calculator, properties are determined using Inlet Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality).

- Pressure = 79.1 psig
- Quality = 0.00
- [Steam Property Calculator] => Specific Enthalpy = 293.8 btu/lbm

Step 3: Determine Desuperheated Outlet Steam Properties
Using the Steam Property Calculator, properties are determined using Outlet Pressure and Desuperheating Temperature.

- Pressure = 156.6 psig
- Temperature = 455.0 °F
- [Steam Property Calculator] => Specific Enthalpy = 1,247.6 btu/lbm

Step 4: Determine Feedwater and Outlet Mass Flows
If the Desuperheated Outlet specific enthalpy is less than the Feedwater specific enthalpy or greater than the Inlet Steam specific enthalpy, the PRV outlet cannot be desuperheated to the set temperature and desuperheating is cancelled.

Flows are determined using mass and energy balance equations:

- Mass Flow = MF
- Specific Enthalpy = SE
- Energy Flow = MF * SE
- Outlet Steam MF = Inlet Steam MF + Feedwater MF
- [Outlet Steam MF * Outlet Steam SE] = [Inlet Steam MF * Inlet Steam SE] + [Feedwater MF * Feedwater SE]
- [Inlet Steam MF + Feedwater MF] * Outlet Steam SE = [Inlet Steam MF * Inlet Steam SE] + [Feedwater MF * Feedwater SE]
- [Inlet Steam MF * Outlet Steam SE] + [Feedwater MF * Outlet Steam SE] = [Inlet Steam MF * Inlet Steam SE] + [Feedwater MF * Feedwater SE]
- [Feedwater MF * Outlet Steam SE] - [Feedwater MF * Feedwater SE] = [Inlet Steam MF * Inlet Steam SE] - [Inlet Steam MF * Outlet Steam SE]
- [Feedwater MF * (Outlet Steam SE - Feedwater SE)] = [Inlet Steam MF * (Inlet Steam SE - Outlet Steam SE)]
- Feedwater MF = Inlet Steam MF * (Inlet Steam SE - Outlet Steam SE) / (Outlet Steam SE - Feedwater SE)
- [Feedwater MF = 3.0 klb/hr = 60.3 klb/hr * (1,294.8 btu/lbm - 1,247.6 btu/lbm) / (1,247.6 btu/lbm - 293.8 btu/lbm)]
- Outlet Steam MF = Inlet Steam MF + Feedwater MF
- [Outlet Steam MF = 63.3 klb/hr = 60.3 klb/hr + 3.0 klb/hr]

Inlet - Pressure [pressure]:

Inlet steam pressure

Inlet - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Inlet - Mass Flow [mass flow]:

Mass flow of the inlet

Outlet Pressure [pressure]:

Outlet steam pressure

If Desuperheating:

Feedwater - Pressure [pressure]:

Feedwater pressure

Feedwater - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the feedwater

Desuperheating Temperature [temperature]:

Target temperature for desuperheating

PRV w/ Desuperheating Calc
Calculates the properties of steam after a pres

Inlet	
Pressure*	226 psig
Temperature *	554.4 °F
Mass Flow *	60.3 klb/hr
Outlet Pressure *	156.6 psig
Desuperheating	
Feedwater	
Pressure*	79.1 psig
Saturated Quality *	0
Desuperheating Temperature *	455 °F
* Required	Enter [reset]

Step 1: Determine Inlet Steam Properties

Inlet steam properties are determined using the **Pressure, Secondary Steam Property, and Mass Flow.**

Step 2: 'If NO Desuperheating': Determine Outlet Steam Properties

Outlet steam properties are determined using the **Outlet Pressure** and inlet steam specific enthalpy. [**'NO Desuperheating' CALCULATION COMPLETE**]

'If Desuperheating': Determine Cooling Water Properties

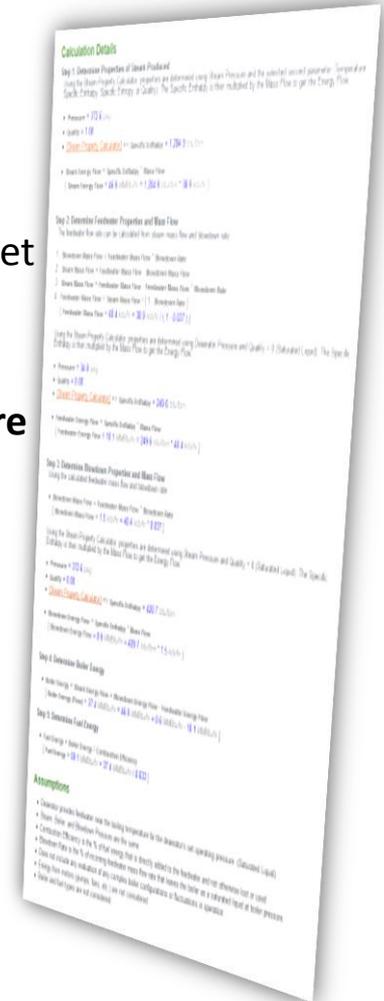
Feedwater steam properties are determined using the **Feedwater-Pressure** and **Feedwater-Secondary Steam Property.**

Step 3: Determine Desuperheated Outlet Steam Properties

Desuperheated outlet steam properties are determined using **Desuperheating Temperature** and **Outlet Pressure.**

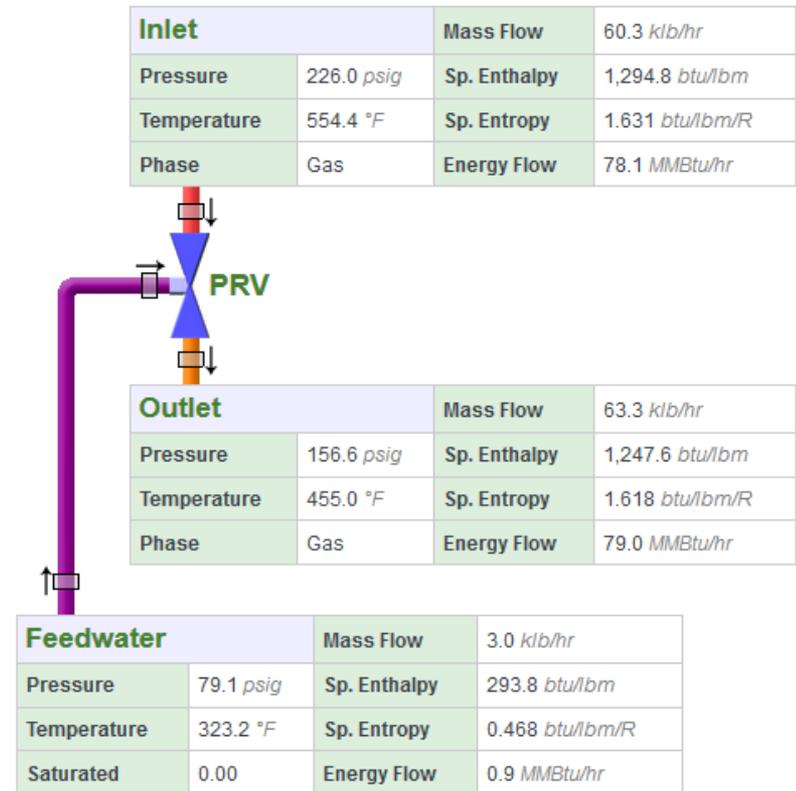
Step 4: Determine Feedwater and Outlet Mass Flows

A mass and energy balance is used to determine the ratio of steam and feedwater required to produce steam at the desuperheated temperature.



The **PRV Calculator** provides the following results:

- Inlet Steam Properties
 - Outlet Steam Properties
- If desuperheating:*
- Feedwater Properties and Mass Flows
 - Total Outlet Steam Mass Flow



The **Header Calculator** determines the combined steam properties of multiple steam inlets.

This simulates situations commonly found in steam systems where multiple sources of steam, with varying pressures and temperatures, are combined into a single steam distribution line, referred to as a steam header.

Header Calculator
Calculates the combined steam properties of multiple steam inlets.

Number of Inlets: 3

Header Pressure *		308.4 psig	
Inlet 1			
Pressure*	553.2 psig		
Temperature *	246.8 °F		
Mass Flow *	52.9 klb/hr		
Inlet 2			
Pressure*	496.5 psig		
Temperature *	117.1 °F		
Mass Flow *	15.2 klb/hr		
Inlet 3			
Pressure*	427.8 psig		
Temperature *	645.6 °F		
Mass Flow *	65.4 klb/hr		

Combined Header			
Mass Flow	133.5 klb/hr		
Pressure	308.4 psig	Sp. Enthalpy	747.1 btu/lbm
Temperature	445.4 °F	Sp. Entropy	0.979 btu/lbm-R
Saturated	0.41	Energy Flow	99.7 MMBtu/hr

Inlet 1		Mass flow	
Mass flow	52.9 klb/hr		
Pressure	553.2 psig	Sp. Enthalpy	216.5 btu/lbm
Temperature	246.8 °F	Sp. Entropy	0.362 btu/lbm-R
Phase	Liquid	Energy Flow	11.5 MMBtu/hr

Inlet 2		Mass flow	
Mass flow	15.2 klb/hr		
Pressure	496.5 psig	Sp. Enthalpy	86.4 btu/lbm
Temperature	117.1 °F	Sp. Entropy	0.100 btu/lbm-R
Phase	Liquid	Energy Flow	1.3 MMBtu/hr

Inlet 3		Mass flow	
Mass flow	65.4 klb/hr		
Pressure	427.8 psig	Sp. Enthalpy	1,329.9 btu/lbm
Temperature	645.6 °F	Sp. Entropy	1.600 btu/lbm-R
Phase	Gas	Energy Flow	87.0 MMBtu/hr

Calculation Details and Assumptions below

Calculation Details

Step 1: Determine the properties and energy flows for the inlets
Using the Steam Property Calculator, properties are determined using Inlet Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality). The Specific Enthalpy is then multiplied by the Mass Flow to get the Energy Flow.

Inlet 1

- Pressure = 553.2 psig
- Temperature = 246.8 °F
- [Steam Property Calculator] => Specific Enthalpy = 216.5 btu/lbm
- Inlet Energy Flow = Specific Enthalpy * Mass Flow
- [Inlet Energy Flow = 11.5 MMBtu/hr = 216.5 btu/lbm * 52.9 klb/hr]

Inlet 2

- Pressure = 496.5 psig
- Temperature = 117.1 °F
- [Steam Property Calculator] => Specific Enthalpy = 86.4 btu/lbm
- Inlet Energy Flow = Specific Enthalpy * Mass Flow
- [Inlet Energy Flow = 1.3 MMBtu/hr = 86.4 btu/lbm * 15.2 klb/hr]

Inlet 3

- Pressure = 427.8 psig
- Temperature = 645.6 °F
- [Steam Property Calculator] => Specific Enthalpy = 1,329.9 btu/lbm
- Inlet Energy Flow = Specific Enthalpy * Mass Flow
- [Inlet Energy Flow = 87.0 MMBtu/hr = 1,329.9 btu/lbm * 65.4 klb/hr]

Step 2: Determine the Header Specific Enthalpy
The header specific enthalpy can be calculated by dividing the Total Inlet Energy Flows by the Total Inlet Mass Flows.

- Total Inlet Energy Flow = 99.7 MMBtu/hr = 11.5 MMBtu/hr + 1.3 MMBtu/hr + 87.0 MMBtu/hr
- Total Inlet Mass Flow = 133.5 klb/hr = 52.9 klb/hr + 15.2 klb/hr + 65.4 klb/hr
- Header Specific Enthalpy = Total Energy Flow / Total Mass Flow
- [Header Specific Enthalpy = 747.1 btu/lbm = 99.7 MMBtu/hr / 133.5 klb/hr]

Step 3: Determine Header Properties
Using the Steam Property Calculator, properties are determined using Header Pressure and the Header Specific Enthalpy.

- Pressure = 308.4 psig
- Specific Enthalpy = 747.1 btu/lbm
- [Steam Property Calculator] => Temperature = 445.4 °F

Number of Inlets [#]:

Specifies the number of steam inlets that the used in the calculation

Header Pressure [pressure]:

The final of the combined steam inlets

For Each Steam Inlet:**Pressure [pressure]:**

Inlet steam pressure

Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Mass Flow [mass flow]:

Mass flow of the inlet

The screenshot shows a web application titled "Header Calculator" with the subtitle "Calculates the combined steam properties of". The interface includes a dropdown menu for "Number of Inlets" set to 3. Below this, there are three sections for "Inlet 1", "Inlet 2", and "Inlet 3". Each inlet section contains input fields for "Pressure*" (in psig), "Temperature" (with a dropdown arrow and units in °F), and "Mass Flow*" (in klb/hr). The "Header Pressure*" field is at the top, showing a value of 388.4 psig. At the bottom of the form, there is a "* Required" label and two buttons: "Enter" and "reset".

Header Calculator	
Calculates the combined steam properties of	
Number of Inlets	3
Header Pressure *	388.4 psig
Inlet 1	
Pressure*	553.2 psig
Temperature	246.8 °F
Mass Flow *	52.9 klb/hr
Inlet 2	
Pressure*	496.5 psig
Temperature	117.1 °F
Mass Flow *	15.2 klb/hr
Inlet 3	
Pressure*	427.8 psig
Temperature	645.6 °F
Mass Flow *	65.4 klb/hr
* Required	Enter reset

Step 1: Determine the properties and energy flows for the inlets

Steam properties for each inlet are determined using the associated **Pressure, Secondary Steam Property, and Steam Mass Flow.**

Step 2: Determine the Header Specific Enthalpy

The header specific enthalpy is calculated by dividing the total inlet energy flows by the total inlet mass flows.

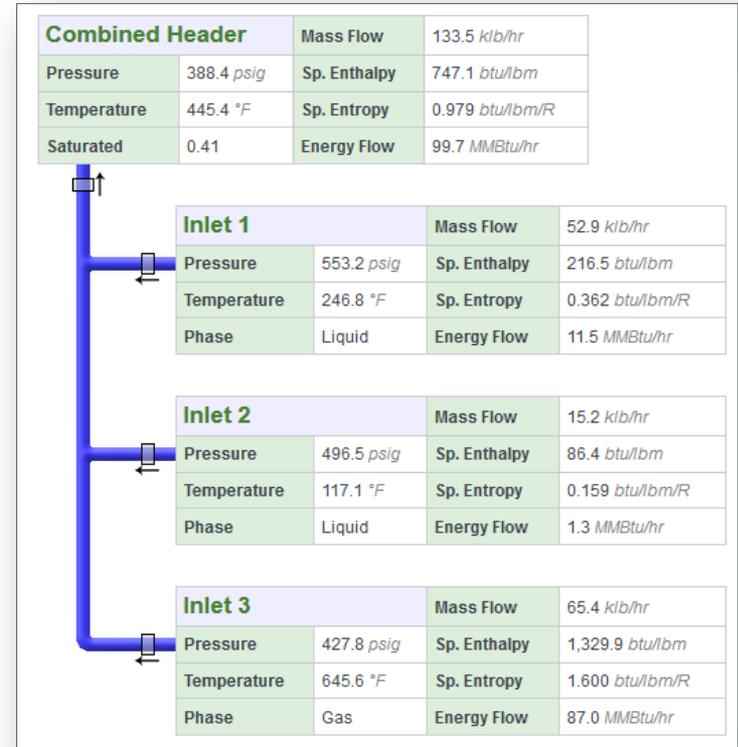
Step 3: Determine Header Properties

The header properties are determined using **Header Pressure** and the header specific enthalpy.



The **Header Calculator** provides the following results:

- Properties and Mass Flows for each Inlet
- The Combined Header Properties and Mass Flow



The **Deaerator Calculator** determines the required water and steam flows for a given feedwater mass flow.

- A *deaerator* is a tank used to remove dissolved gases from the feedwater before being sent to the boiler
- The solubility of gases in water is reduced as the water temperature increases. Therefore deaerators increase feedwater to near boiling temperature to remove as much gas as possible.
- The small amount of steam is vented in the process of venting the gases
- Steam is commonly used as the heat source for the deaerator

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Steam Calculators

EEER - Advanced Manufacturing Office - Steam Calculators - Deaerator Calculator

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Deaerator Calculator
Determines the required water and steam flows for a required feedwater mass flow.

Deaerator Pressure *	30.6	psig
Vent Rate *	0.4	%
Feedwater Mass Flow *	45.7	klb/hr

Feedwater	Mass Flow	45.7	klb/hr		
Pressure	30.6	psig	Sp. Enthalpy	243.9	btu/lbm
Temperature	274.8	°F	Sp. Entropy	0.403	btu/lbm-R
Saturated	0.00	Energy Flow	11.1	MBtu/hr	

Vented Steam	Mass Flow	0.2	klb/hr		
Pressure	30.6	psig	Sp. Enthalpy	1,172.3	btu/lbm
Temperature	274.8	°F	Sp. Entropy	1.907	btu/lbm-R
Saturated	1.00	Energy Flow	0.2	MBtu/hr	

Inlet Water	Mass Flow	30.8	klb/hr		
Pressure	2.6	psig	Sp. Enthalpy	29.9	btu/lbm
Temperature	61.8	°F	Sp. Entropy	0.059	btu/lbm-R
Phase	Liquid	Energy Flow	1.2	MBtu/hr	

Inlet Steam	Mass Flow	6.1	klb/hr		
Pressure	57.9	psig	Sp. Enthalpy	1,670.2	btu/lbm
Temperature	1,258.7	°F	Sp. Entropy	2.043	btu/lbm-R
Phase	Gas	Energy Flow	10.2	MBtu/hr	

Diagram: A schematic showing a central 'Deaerator' unit. It has an 'Inlet Water' stream (purple) entering from the left, an 'Inlet Steam' stream (red) entering from the bottom, and a 'Vented Steam' stream (red) exiting to the right. The 'Deaerator' also has a 'Feedwater' stream (purple) exiting to the right.

Calculation Details and Assumptions below

Calculation Details

Step 1: Determine Inlet Water Properties
Using the Steam Property Calculator, properties are determined using Inlet Water Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality):

- Pressure = 2.6 psig
- Temperature = 61.8 °F
- [Steam Property Calculator] => Specific Enthalpy = 29.9 btu/lbm

Step 2: Determine Inlet Steam Properties
Using the Steam Property Calculator, properties are determined using Inlet Steam Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality):

- Pressure = 57.9 psig
- Temperature = 1,258.7 °F
- [Steam Property Calculator] => Specific Enthalpy = 1,670.2 btu/lbm

Step 3: Determine Feedwater and Vented Steam Properties

- Pressure = 30.6 psig
- [Saturated Properties Calculator] =>
 - Saturated Liquid Specific Enthalpy = 243.9 btu/lbm
 - Saturated Gas Specific Enthalpy = 1,172.3 btu/lbm

Step 4: Determine Feedwater and Vented Mass Flows and Total Outlet Energy Flows

- Vented Steam Mass Flow = Vent Rate * Feedwater Mass Flow
[Vented Steam Mass Flow = 0.2 klb/hr = 0.4 * 45.7 klb/hr]
- Total DA Mass Flow = Vented Steam Mass Flow + Feedwater Mass Flow
[Total DA Mass Flow = 45.9 klb/hr = 0.2 klb/hr + 45.7 klb/hr]
- Total Outlet Energy Flow = [Feedwater Specific Enthalpy * Feedwater Mass Flow] + [Vented Steam Specific Enthalpy * Vented Steam Mass Flow]
[Total Outlet Energy Flow = 11.4 MBtu/hr = 243.9 btu/lbm * 45.7 klb/hr + 1,172.3 btu/lbm * 0.2 klb/hr]

Deaerator Pressure [pressure]:

Operating pressure of the deaerator

Vent Rate [%]:

Deaerator vent rate as a % of feedwater mass flow

Feedwater Mass Flow [mass flow]:

Mass flow of the feedwater sent to the boiler

Water - Pressure [pressure]:

Inlet water pressure

Water - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet water

Steam - Pressure [pressure]:

Inlet steam pressure

Steam - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Deaerator Calculator	
Determines the required water and steam flows	
Deaerator Pressure *	30.6 psig
Vent Rate *	0.4 %
Feedwater Mass Flow *	45.7 klb/hr
Water	
Pressure*	2.6 psig
Temperature ▾ *	61.8 °F
Steam	
Pressure*	57.9 psig
Temperature ▾ *	1258.7 °F
* Required	Enter [reset]

Step 1: Determine Inlet Water Properties

Inlet water properties are determined using the associated **Pressure** and **Secondary Property**.

Step 2: Determine Inlet Steam Properties

Inlet steam properties are determined using the associated **Steam Pressure** and **Secondary Steam Property**.

Step 3: Determine Feedwater and Vented Steam Properties

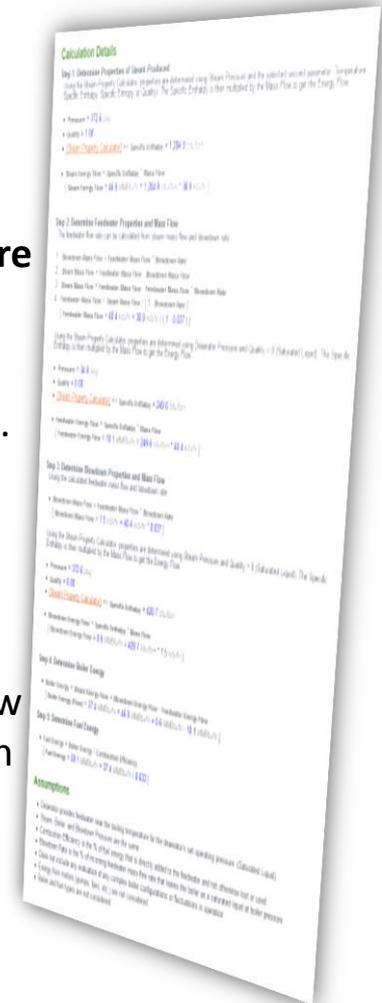
The saturated steam properties are calculated for the **Deaerator Pressure**. Feedwater properties set to that of the saturated liquid and the vented steam is set to that of the saturated gas/vapor.

Step 4: Determine Feedwater and Vented Mass Flows and Total Outlet Energy Flows

The vented steam mass flow is determined using the Feedwater Mass Flow and Vent Rate. The energy flow of the vented steam and feedwater is then totaled.

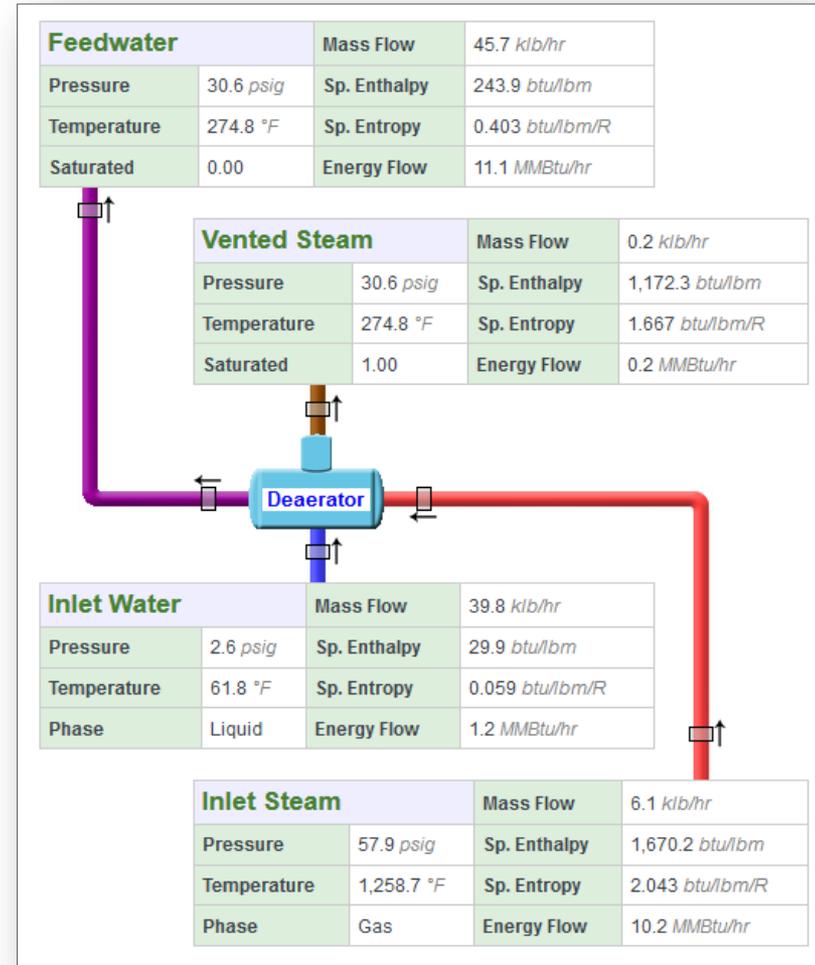
Step 5: Determine Inlet Water and Steam Mass Flows

A mass and energy balance is used to determine the ratio of inlet water and inlet steam required to match the outlet mass and energy flows.



The **Deaerator Calculator** provides the following results:

- Properties and Mass Flows for:
 - Inlet Water
 - Inlet Steam
 - Feedwater
 - Vented Steam



The Steam Turbine Calculator

generates a basic steam turbine model, solving for either:

- **Outlet Steam Conditions** – given inlet steam conditions and isentropic efficiency
- **Isentropic Efficiency** – given inlet and outlet steam conditions

Users also have the option to enter either the steam mass flow or power generated and the calculator determines the value of the other

Steam Calculators

ES&E - Advanced Manufacturing Office - Steam Calculators - Steam Turbine Calculator

Steam Turbine Calculator

Calculates the energy generated or steam outlet conditions for a steam turbine.

Solve for:		Inlet Steam		Mass Flow																	
Outlet Properties		Pressure	565.4 psig	Sp. Enthalpy	1,563.8 Btu/lbm																
Inlet Steam		Temperature	1,064.3 °F	Sp. Entropy	1,744 Btu/lbm-R																
Turbine Properties		Phase	Gas	Energy Flow	61.1 MWhr/hr																
Pressure*	565.4 psig	Isentropic Efficiency	75.7 %	Energy Out	3.3 MWhr/hr																
Temperature	1,064.3 °F	Generator Efficiency	96.2 %	Power Out	926.4 kW																
Selected Turbine Property	Mass Flow																				
Mass Flow*	39.3 lb/hr	<table border="1"> <thead> <tr> <th colspan="2">Outlet Steam</th> <th colspan="2">Mass Flow</th> </tr> </thead> <tbody> <tr> <td>Pressure</td> <td>266.1 psig</td> <td>Sp. Enthalpy</td> <td>1,470.1 Btu/lbm</td> </tr> <tr> <td>Temperature</td> <td>891.7 °F</td> <td>Sp. Entropy</td> <td>1,764 Btu/lbm-R</td> </tr> <tr> <td>Phase</td> <td>Gas</td> <td>Energy Flow</td> <td>61.1 MWhr/hr</td> </tr> </tbody> </table>				Outlet Steam		Mass Flow		Pressure	266.1 psig	Sp. Enthalpy	1,470.1 Btu/lbm	Temperature	891.7 °F	Sp. Entropy	1,764 Btu/lbm-R	Phase	Gas	Energy Flow	61.1 MWhr/hr
Outlet Steam		Mass Flow																			
Pressure	266.1 psig	Sp. Enthalpy	1,470.1 Btu/lbm																		
Temperature	891.7 °F	Sp. Entropy	1,764 Btu/lbm-R																		
Phase	Gas	Energy Flow	61.1 MWhr/hr																		
Isentropic Efficiency*	75.7 %																				
Generator Efficiency*	96.2 %																				
Outlet Steam																					
Pressure*	266.1 psig																				
Temperature	891.7 °F																				
Phase	Gas																				

*Required

*Example: Solve for Outlet Properties

Example:

Calculation Details and Assumptions below

Calculation Details

Step 1: Determine Inlet Properties
Using the Steam Property Calculator, properties are determined using Inlet Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality). The Specific Enthalpy is then multiplied by the Mass Flow to get the Energy Flow.

- Pressure = 565.4 psig
- Temperature = 1,064.3 °F
- ⇒ Specific Enthalpy = 1,563.8 Btu/lbm
- Mass Flow = 39.3 lb/hr
- Inlet Energy Flow = Specific Enthalpy * Mass Flow
Inlet Energy Flow = 61.1 MWhr/hr = (1,563.8 Btu/lbm * 39.3 lb/hr)

Step 2: Calculate Ideal Outlet Properties (Inlet Entropy equals Outlet Entropy)

- Pressure = 266.1 psig
- Specific Enthalpy = 1,474 Btu/lbm-R
- ⇒ Specific Enthalpy = 1,443.3 Btu/lbm

Step 3: If solve for 'Isentropic Efficiency', Determine Outlet Properties
Using the outlet specific enthalpy, calculate the isentropic efficiency.

- Isentropic Efficiency = (Inlet Specific Enthalpy - Outlet Specific Enthalpy) / (Inlet Specific Enthalpy - IDEAL Outlet Specific Enthalpy)

Step 3: If solve for 'Outlet Properties', Determine Outlet Specific Enthalpy

- Isentropic Efficiency = (Inlet Specific Enthalpy - Outlet Specific Enthalpy) / (Inlet Specific Enthalpy - IDEAL Outlet Specific Enthalpy)
- Isentropic Efficiency * (Inlet Specific Enthalpy - IDEAL Outlet Specific Enthalpy) = Inlet Specific Enthalpy - Outlet Specific Enthalpy
- Outlet Specific Enthalpy = Inlet Specific Enthalpy - Isentropic Efficiency * (Inlet Specific Enthalpy - IDEAL Outlet Specific Enthalpy)
(Outlet Specific Enthalpy = 1,475.3 Btu/lbm = 1,563.8 Btu/lbm - 75.7% * (1,563.8 Btu/lbm - 1,443.3 Btu/lbm))

Using the outlet specific enthalpy, calculate the outlet properties:

- Pressure = 266.1 psig
- Specific Enthalpy = 1,470.1 Btu/lbm
- ⇒ Temperature = 891.7 °F

Step 4: Calculate Steam Turbine Energy Out and Generation (Power Out)

- Energy Out = (Inlet Specific Enthalpy - Outlet Specific Enthalpy) * Mass Flow
Energy Out = 3.3 MWhr/hr = (1,563.8 Btu/lbm - 1,470.1 Btu/lbm) * 39.3 lb/hr
- Power Out = Energy Out * Generator Efficiency
Power Out = 926.4 kW = 3.3 MWhr/hr * 96.2 %

Assumptions

- Inlet Mass Flows equal Outlet Mass Flow

-SOLVING FOR Outlet Properties-

Inlet Steam - Pressure [pressure]:

Pressure of inlet steam

Inlet Steam - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Isentropic Efficiency [%]:

The energy actually removed as a percent (%) of the energy removed if the turbine were an isentropic process.

Generator Efficiency [%]:

The percent of the energy extracted by the turbine that is converted to power

Either Mass Flow or Power Out:

Mass Flow [mass flow]:

Mass flow of steam

Power Out [power]:

Mass flow of the feedwater sent to the boiler

Outlet Steam - Pressure [pressure]:

Outlet water pressure

Steam Turbine Calculator
Calculates the energy generated or steam out

Solve for:	
Outlet Properties	
Inlet Steam	
Pressure*	565.4 psig
Temperature *	1064.3 °F
Turbine Properties	
Selected Turbine Property	Mass Flow
Mass Flow *	39.3 klb/hr
Isentropic Efficiency *	75.7 %
Generator Efficiency *	96.2 %
Outlet Steam	
Pressure*	266.1 psig
* Required	Enter [reset]

-SOLVING FOR Isentropic Efficiency-

Inlet Steam - Pressure [pressure]:

Pressure of inlet steam

Inlet Steam - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Generator Efficiency [%]:

The percent of the energy extracted by the turbine that is converted to power

Either Mass Flow or Power Out:

Mass Flow [mass flow]:

Mass flow of steam

Power Out [power]:

Mass flow of the feedwater sent to the boiler

Outlet Steam - Pressure [pressure]:

Outlet water pressure

Outlet Steam - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the outlet steam

Steam Turbine Calculator
Calculates the energy generated or steam out

Solve for:
Outlet Properties ▾

Inlet Steam

Pressure*	565.4	psig
Temperature ▾ *	1064.3	*F

Turbine Properties

Selected Turbine Property	Mass Flow ▾	
Mass Flow *	39.3	kilb/hr
Isentropic Efficiency *	75.7	%
Generator Efficiency *	96.2	%

Outlet Steam

Pressure*	266.1	psig
-----------	-------	------

* Required Enter reset

Step 1: Determine Inlet Properties

Inlet steam properties are determined using the **Pressure** and **Secondary Property**.

Step 2: Calculate Ideal Outlet Properties (Inlet Entropy equals Outlet Entropy)

Ideal outlet steam properties are determined using the associated **Outlet Steam Pressure** and inlet specific entropy. The ideal case assumes that no entropy is created in the turbine.

Step 3: If solving for 'Isentropic Efficiency', Determine Outlet Properties

Outlet steam properties are determined using the **Outlet Steam Pressure** and **Outlet Secondary Steam Property**.

Step 3: If solving for 'Outlet Properties', Determine Outlet Specific Enthalpy

The outlet specific enthalpy is calculated using the **Isentropic Efficiency**, inlet specific enthalpy, and ideal outlet specific enthalpy. The outlet specific enthalpy and outlet pressure are used to determine the outlet properties.

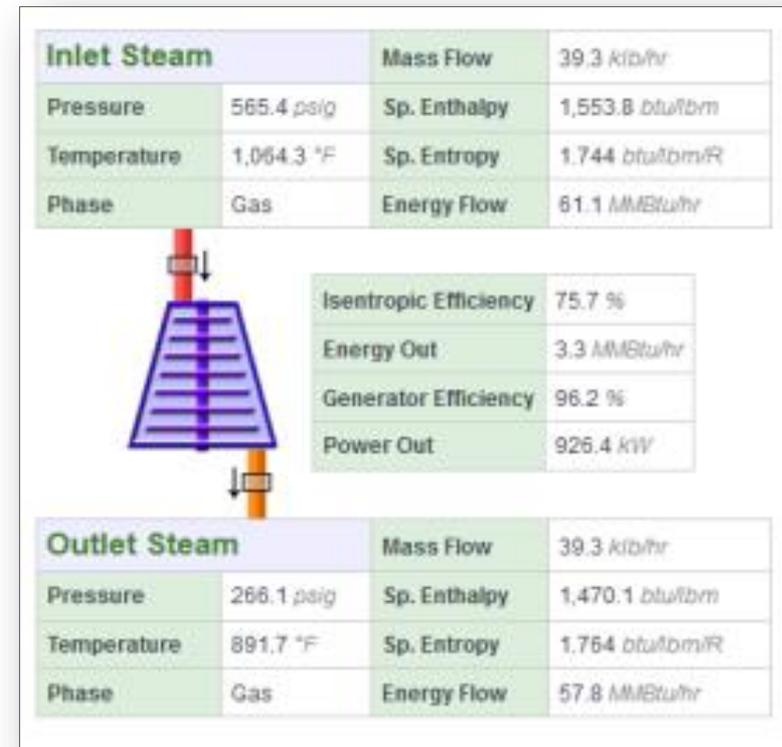
Step 4: Calculate Steam Turbine Energy Out and Generation (Power Out)

The difference between the outlet and inlet steam energy flows are used to determine the energy extracted from the steam (Energy Out). The **Generation Efficiency** is then used to determine the power generated (Power Out)



The **Steam Turbine Calculator** provides the following results:

- Inlet Steam Properties
- Outlet Steam Properties
- Isentropic Efficiency
- Energy Out (*energy extracted*)
- Power Out (*power generated*)



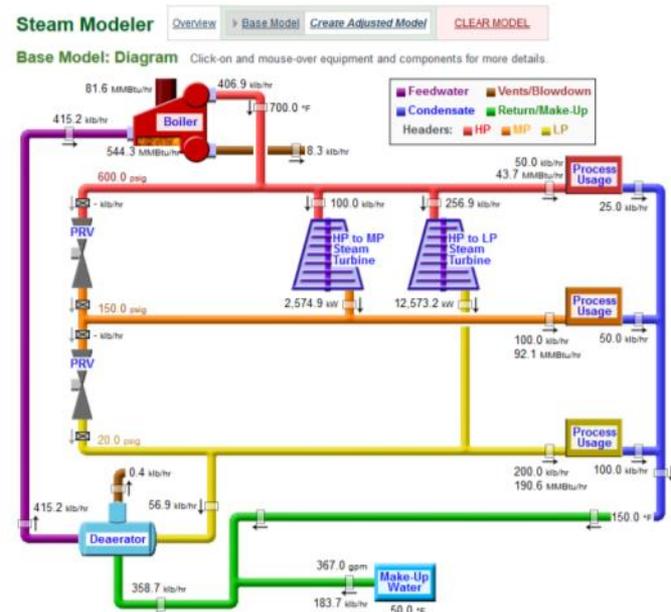
Steam System Modeler

A 1-3 header steam system model can be generated with the associated PRVs, steam turbines, flash tanks, heat losses, and condensate return conditions. Users can then evaluate the impact of a significant number of adjustments to the model.

SSMT is capable of creating a basic *steam system model* that can be used to better understand the current operating conditions of a system and evaluate the impacts of numerous adjustments. Steam models include the following components:

- Boiler
- Deaerator
- 1 to 3 Steam Pressure Headers
- Backpressure Steam Turbines
- Condensing Steam Turbine
- Flash Tanks
- Pressure Reducing Values (PRVs)
- Blowdown Heat Exchanger

Models are NOT saved online and must be manually downloaded and reload in later sessions.



Base Model

The initial steam system model created by the user.

Adjusted Model

The model generated by applying all selected adjustments to the base model.

SSAT

The Steam System Assessment Tool which was the previous steam system modeler. The modeler is able to load examples based on the default models used by SSAT.

HP, MP, and LP

High Pressure, Medium Pressure, and Low Pressure. These terms are just relative to each other and do not have further meaning.

The basic steps for using the Steam System Modeler are as follows:

Step 1: Generate a Base Model

There are 3 ways to generate a Base Model:

- Manually enter specific steam system details
- Load an example
- Reload a previously downloaded model

Step 2: Generate an Adjusted Model

- A series of projects and system adjustments may be selected and combined with the Base Model to generate an Adjusted Model.

Step 3: Compare Base Model to Adjusted Model

- A summary of Base Model vs Adjusted Model metrics will be generated once both a Base Model and Adjusted Model have been created.
- A generated model may also be downloaded as an excel file and re-uploaded later.

The initial generation of a base model only requires the successful submission on 1 form which is broken into 4 sections (*additional details on the following pages*):

Boiler Details

Boiler and deaerator related information

General Details

Unit costs, operating hours, make-up water, and electricity

Header Details

Pressures, steam usage, and other related data

Steam Turbine Details

Operating conditions for the various possible steam turbines configuration

Steam Modeler [Overview](#) [Create Base Model](#) [Reload Model](#)

Boiler Details

Boiler Combustion Efficiency*	85	%
Fuel Type*	Natural Gas	
Blowdown Rate*	2	%
Is the blowdown flashed?*	No	
Preheat Make-Up Water with Blowdowns*	No	
Steam Temperature*		°F
Deaerator Vent Rate*	0.1	%
Deaerator Pressure*		psig

General Details

Site Power Import*		kW
Electricity Unit Cost*		\$/kWh
Yearly Operating Hours*		hrs
Make-Up Water Unit Cost*		\$/gal
Make-Up Water Temperature*	50	°F
Fuel Unit Cost*		\$/MMBtu

Header Details

Number of Headers: 3 - Header ▾

HEADERS	HP	MP	LP	
Pressure*				psig
Process Steam Usage*				klb/hr
Condensate Recovery*				%
Flash Condensate into Header	No ▾	No ▾		
Condensate Return Temperature*	150			°F
Flash Condensate Return*	No ▾			
Heat Loss*	0.1	0.1	0.1	%
Desuperheat Steam into MP*	No ▾	370		°F
Desuperheat Steam into LP*	No ▾	270		°F

Steam Turbine Details

Condensing Turbine	<input checked="" type="checkbox"/> On/Off
HP to LP Turbine	<input checked="" type="checkbox"/> On/Off
HP to MP Turbine	<input checked="" type="checkbox"/> On/Off
MP to LP Turbine	<input checked="" type="checkbox"/> On/Off

[GENERATE BASE MODEL](#)

Boiler Combustion Efficiency [%]:

% of the fuel energy that is transferred to the boiler water and steam

Fuel Type [fuel type]:

Primary fuel for the boiler

Blowdown Rate [%]:

% of feedwater being drained from the boiler as a saturated liquid to reduce dissolved solids concentration

Is the blowdown flashed? [yes/no]:

Indicate if model should include flashing of blowdown

Preheat Make-Up Water with Blowdown [yes/no | temperature]:

Indicate if mode should preheat make-up water with blowdown. If 'Yes', an approach temperature can also be set

Steam Temperature [temperature]:

Temperature of the generated steam which must be equal to or greater than the boiling temperature

Deaerator Vent Rate[%]:

Vent rate as a % of feedwater mass flow

Deaerator Pressure [pressure]:

Operating pressure of the deaerator

Boiler Details	
Boiler Combustion Efficiency*	85 %
Fuel Type*	Natural Gas
Blowdown Rate*	2 %
Is the blowdown flashed?*	No
Preheat Make-Up Water with Blowdown*	No
Steam Temperature*	°F
Deaerator Vent Rate*	0.1 %
Deaerator Pressure*	psig

Site Power Import [power]:

The average power import rate of electricity for the site which is primarily used to evaluate the potential of steam turbine generation

Electricity Unit Cost [\$/electricity]:

The unit cost associated with electricity

Yearly Operating Hours [hours]:

Total hours of operation for the steam system

Make-Up Water Unit Cost [\$/volume]:

The unit cost associated with make-up water

Make-Up Water Temperature [temperature]:

The average temperature of the make-up water

Fuel Unit Cost [\$/energy]:

The unit cost associated with the fuel

General Details	
Site Power Import*	<input type="text"/> kW
Electricity Unit Cost*	<input type="text"/> \$ / kWh
Yearly Operating Hours*	<input type="text"/> hrs
Make-Up Water Unit Cost*	<input type="text"/> \$ / gal
Make-Up Water Temperature*	50 <input type="text"/> °F
Fuel Unit Cost*	<input type="text"/> \$ / MMBtu

Number of Headers [#]:

The total number of steam headers (1-3)

For each Header:

Pressure [pressure]:

Operating pressure of the header

Process Steam Usage[mass flow]:

The amount of header steam used for processes

Condensate Recovery [%]:

% of process steam recovered as condensate

Flash Condensate into Header [yes/no]:

Indicate if model should flash condensate into the lower pressure header (for 3 headers: HP into MP, MP to LP)

Condensate Return Temperature [temperature]:

Average temperature of the returned combined condensate

Flash Condensate Return [yes/no]:

Indicate if model should flash returned condensate into the lowest pressure header

Heat Loss [%]:

% heat loss for each header adjusting for numerous sources of heat loss in a header

Desuperheat Steam into MP/LP [yes/no | temperature]:

Indicate if PRV is also desuperheating and set the target temperature

Header Details				
Number of Headers	3 - Header ▾			
HEADERS	HP	MP	LP	
Pressure*	<input type="text"/>	<input type="text"/>	<input type="text"/>	psig
Process Steam Usage*	<input type="text"/>	<input type="text"/>	<input type="text"/>	kib/hr
Condensate Recovery*	<input type="text"/>	<input type="text"/>	<input type="text"/>	%
Flash Condensate into Header		No ▾	No ▾	
Condensate Return Temperature*	150 <input type="text"/>	°F		
Flash Condensate Return*	No ▾			
Heat Loss*	0.1 <input type="text"/>	0.1 <input type="text"/>	0.1 <input type="text"/>	%
Desuperheat Steam into MP*	No ▾	370 <input type="text"/>	°F	
Desuperheat Steam into LP*	No ▾	270 <input type="text"/>	°F	

Each Steam Turbine can be turned ON/OFF and the following operational conditions can be set:

Isentropic Efficiency [%]:

The energy actually removed as a percent (%) of the energy removed if the turbine were an isentropic process (*entropy in = entropy out*)

Generator Efficiency [%]:

The percent of the energy extracted by the turbine that is converted to electricity (*power*)

Condenser Pressure [vacuum pressure] (condensing turbine only):

The vacuum pressure at the exit of the turbine

Operation Type (condensing turbine can only use Steam Flow and Power Gen):

Balance Header

Allows enough steam flow to balance lower pressure header

Steam Flow [mass flow]:

Operates at this specific steam mass flow

Flow Range [mass flow]:

Sets minimum and maximum flow based on balancing requirements

Power Generation [power]:

Operates at this specific power generation

Power Range [power]:

Sets minimum and maximum power generation based on balancing requirements

Steam Turbine Details

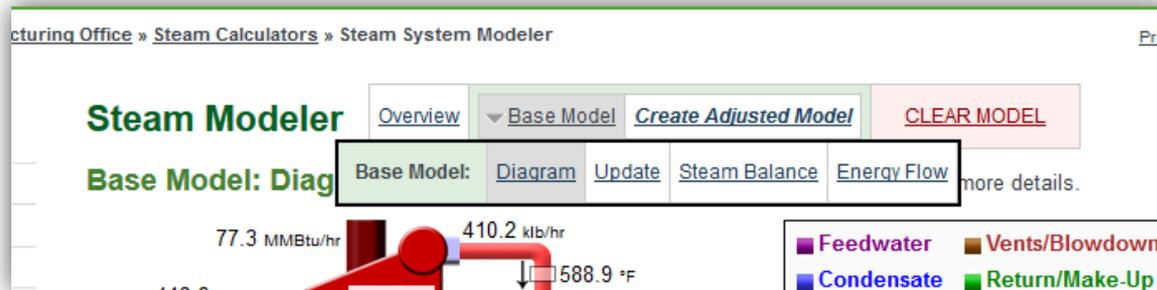
Condensing Turbine	<input checked="" type="checkbox"/> On/Off
Isentropic Efficiency*	65 %
Generation Efficiency*	98 %
Condenser Pressure*	725.2 psia
Operation Type*	Steam Flow
Fixed Flow*	100 klb/hr

HP to LP Turbine	<input checked="" type="checkbox"/> On/Off
Isentropic Efficiency*	65 %
Generation Efficiency*	98 %
Operation Type*	Flow Range
Minimum Flow*	Balance Header Steam Flow Flow Range Power Generation Power Range
Maximum Flow*	
HP to MP Turbine	<input type="checkbox"/> On/Off
MP to LP Turbine	<input type="checkbox"/> On/Off

Once the base model has successfully been generated, user may:

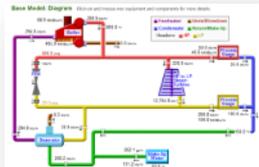
- View a **Diagram** of the Base Model
- **Update** the Base Model by modifying the initial base model form
- View a **Steam Balance** of the Base Model
- View a Sankey diagram of the base model **Energy Flow**
- And create an Adjusted version of the base model

*Moving the mouse over “Base Model”
will open the menu of viewing options*

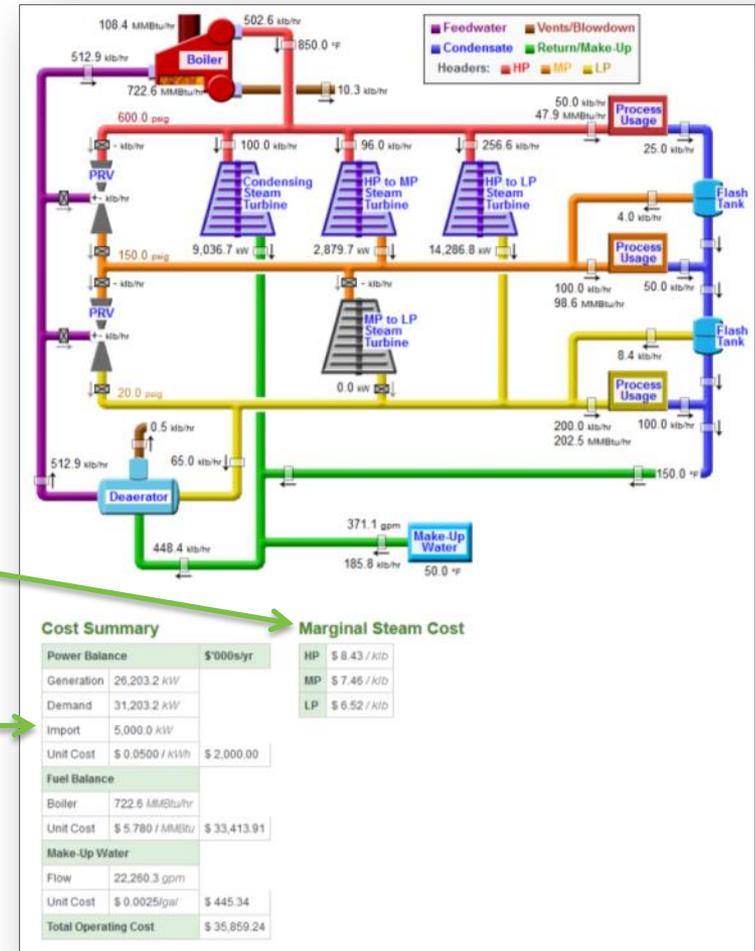


The Steam System Modeler Diagram includes:

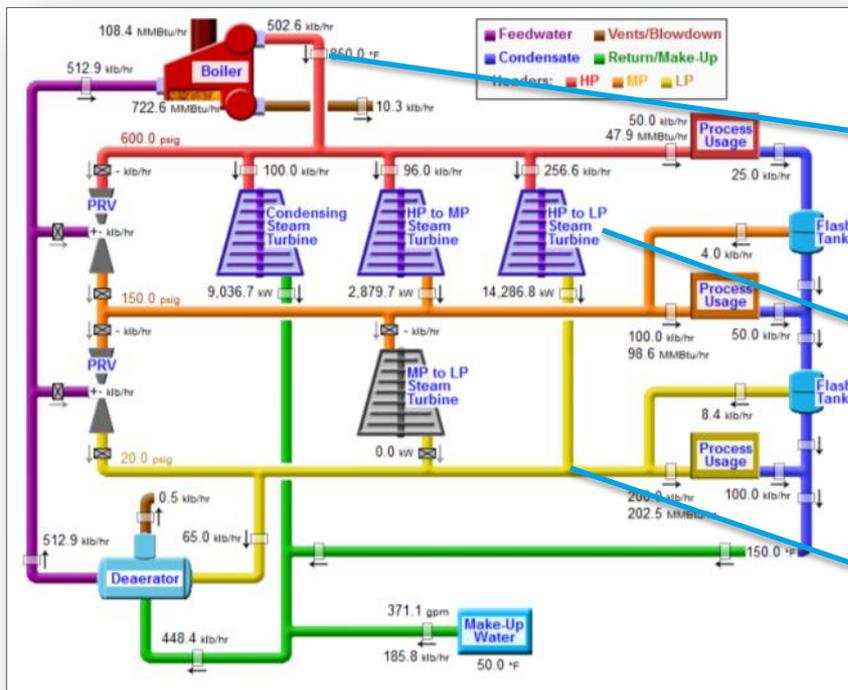
- A customized layout of equipment and headers dependent on the specific model
- Example:



- Marginal Steam Costs by Header
 - these are marginal costs associated with a small increase or decrease in steam usage
- Power, Fuel, and Water Cost Summary
- Moving the mouse over each piece of equipment and steam point provides additional information
- Clicking on a specific piece of equipment provides even more detail (cont.)



All plants of the diagram are interactive and provide additional details when a mouse is moved over it. The diagram below has **over 50 different components** that provide specific additional pop-up details:



Examples:

Boiler Steam	Mass Flow	403.4 <i>klb/hr</i>
Temperature	850.0 °F	Sp. Enthalpy 1,435.1 <i>btu/lbm</i>
Pressure	600.0 <i>psig</i>	Sp. Entropy 1.653 <i>btu/lbm/R</i>
Phase	Gas	

HP to LP Turbine			
Isentropic Eff	65.0 %	Energy Out	48.1 <i>MMBtu/hr</i>
Generation Eff	100.0 %	Power Out	14,108.9 <i>kW</i>
<i>Click on Turbine for Details</i>			

LP Header Details			
Pressure	20.0 <i>psig</i>	Mass Flow	253.4 <i>klb/hr</i>
Energy Loss %	0.10 %	Energy Loss	0.3 <i>MMBtu/hr</i>
Temperature	410.7 °F	Phase	Gas

Clicking on specific equipment will open an in-page window with complete details on all associated steam properties and operational conditions.

Users also have the option to copy the properties of the selected piece of equipment to the associated individual equipment calculator. This allows modifications of the equipment to be evaluated without having to modify the entire model.

The screenshot displays the 'Steam Calculators' interface. The main window shows a 'Base Model: Diagram' with a steam system layout. A pop-up window titled 'HP to MP Turbine' provides detailed data for a selected turbine. Below is a table of the turbine's properties:

	Inlet	Outlet Ideal	Outlet	Units
Pressure	600.0	150.0	150.0	psig
Temperature	587.0	365.9	376.8	°F
Specific Enthalpy	1,279.9	1,161.6	1,203.1	btu/lbm
Specific Entropy	1.521	1.521	1.571	btu/lbm/R
Phase / Quality	Gas	0.96	Gas	
Specific Volume	0.903	2.647	2.809	ft ³ /lb
Mass Flow	100.0	-	100.0	klb/hr
Energy Flow	128.0	-	120.3	MMBtu/hr
Isentropic Efficiency	65.0 %			
Energy Out	7.7 MMBtu/hr			
Generator Efficiency	100.0 %			
Power Out	2,253.4 kW			

At the bottom of the calculator window, there is a button labeled 'Copy to Steam Turbine Calculator' and a note: '*May include slight rounding errors.'

This is a smaller view of the 'Steam Turbine Calculator' window, showing a grid of input and output fields for turbine parameters.

Users can view a detailed *mass and energy balance*. This collectively referred to a “**Steam Balance**” in SSMT.

- Validates that the steam system model has properly converged
- Includes all key sections of the model. For a 3 header steam model the sections include:
 - System Overall
 - HP Header
 - MP Header
 - LP Header
 - Condensate Return
 - Feedwater

Steam Balance

Mass and Energy flows are listed and summed system wide for and the model has correctly converged.

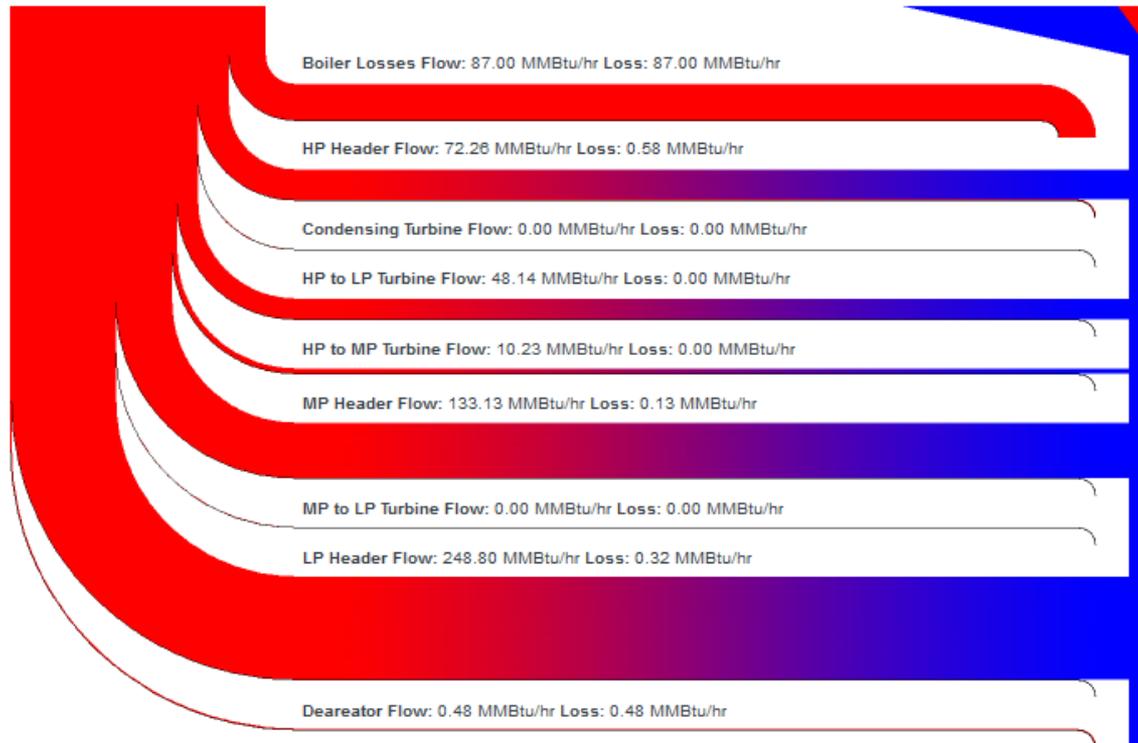
** TOTALs may include a small difference from rounding

System	Base Model		
	klb/hr	MMBtu/hr	btu/lbm
Boiler Energy	-	580.0	
Boiler Energy Losses	-	-87.0	
Cond Turbine	-	-	
Cond Turbine Losses	-	-	
HP to MP Turbine	-	-10.2	
MP to LP Turbine	-	-	
HP Energy Losses	-	-0.6	
HP Process Losses	-25.0	-59.8	
MP Energy Losses	-	-0.1	
MP Condensate Losses	-50.0	-116.1	
LP Energy Losses	-	-0.3	
LP Condensate Losses	-100.0	-225.7	
LP Vented Steam	-	-	
Make Up Water	183.6	3.3	18.1
Blowdown	-8.2	-3.9	474.8
Condensate Flash	-	-	
Condensate Heat Loss	-	-30.9	
Deaerator Steam Vent	-0.4	-0.5	1,163.9
TOTAL:	-	-	

HP Header	Base Model		
	klb/hr	MMBtu/hr	btu/lbm
Boiler Steam	403.4	578.9	1,435.1
Condensing Turbine Inlet	-	-	
HP to MP Turbine Inlet	-100.0	-143.4	1,433.7
HP to LP Turbine Inlet	-253.4	-363.3	1,433.7
HP to MP PRV Inlet	-	-	
HP Processes	-50.0	-71.7	1,433.7
HP Energy Losses	-	-0.6	
TOTAL:	-	-	

The energy flows of both the base model and adjusted models can be viewed in **Sankey diagrams** as seen below. Each segment is dynamically adjusted to be proportionate to the associated energy flow.

Base Energy Flows



Adjusted Models are created by adding various adjustments, relative to the Base Model, grouped in these major areas: *(additional details on the following pages)*

- Adjust General Operation
- Adjust Unit Costs
- Adjust Steam Demand
- Adjust Boiler Operation
- Adjust Steam Turbine Operation
- Adjust Condensate Handling
- Adjust Insulation / Heat Loss

Notes:

- Users must select at least 1 adjustment
- Updates to the base model automatically update the adjusted model
- The adjusted model represents **combined impacts** of all adjustments on the base model



Select Potential Adjustments/Projects

Unless adjusted Steam Demands are set, the Adjusted Model's that all processes will still required the same amount of energy.

- Adjust General Operation
- Adjust Unit Costs
- Adjust Steam Demand (only 1 may be selected)
- Adjust Boiler Operation
- Adjust Steam Turbine Operation
- Adjust Condensate Handling
- Adjust Insulation / Heat Loss

GENERATE ADJUSTED MODEL

General Operation adjustments include:

- **Operating Hours** [[hours](#)]
 - This reflects a potential change in yearly operation of the steam system
- **Average Make-Up Water Temperature** [[temperature](#)]
 - By changing sources, average make-up water temperatures may also change

<input checked="" type="checkbox"/> Adjust General Operation			
<input checked="" type="checkbox"/> Modify Operating Hours			
Initial Operating Hours	8,000 hrs	NEW Operating Hours*	<input type="text"/> hrs
<input checked="" type="checkbox"/> Modify Make-Up Water Temperature			
Initial Make-Up Water Temperature	50.0 °F	NEW Make-Up Water Temperature*	50 <input type="text"/> °F

Unit Costs adjustments include:

- **Electricity Unit Cost** [$\$/\text{electricity}$]
 - Electricity prices are generally always subject to change
- **Fuel Unit Cost** [$\$/\text{energy}$]
 - Normal market fluctuations as well as switching fuels and/or suppliers can adjust cost
- **Make-Up Water Unit Cost** [$\$/\text{volume}$]
 - Changes in water source, supplier, and water treatment can all impact water cost

<input checked="" type="checkbox"/> Adjust Unit Costs			
<input checked="" type="checkbox"/> Modify Electricity Unit Cost			
Initial Electricity Unit Cost	\$ 0.0500 / kWh	NEW Electricity Unit Cost*	<input type="text"/> \$ / kWh
<input checked="" type="checkbox"/> Modify Fuel Unit Cost			
Initial Fuel Unit Cost	\$ 5.7800 / MMBtu	NEW Fuel Unit Cost*	<input type="text"/> \$ / MMBtu
<input checked="" type="checkbox"/> Modify Make-Up Unit Cost			
Initial Make-Up Water Unit Cost	\$ 0.0025 / gal	NEW Make-Up Water Unit Cost*	<input type="text"/> \$ / gal

Steam Demand adjustments may include only 1 of the 2 subcategories:

Energy Demand – fixes the energy usage levels for each headers process steam usage. Therefore if header steam properties change, the process steam usage will be adjusted to match the energy usage.

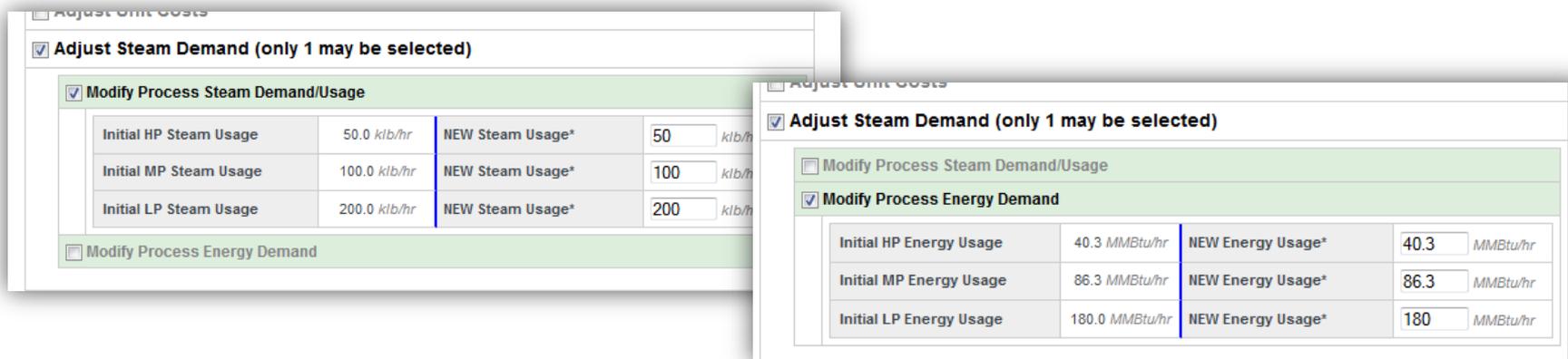
Energy Usage (for each header) [energy]

Any change in a systems process steam requirements would change energy usage requirements

Steam Demand/Usage – fixes the steam usage levels for each header’s process steam usage regardless of changes in steam properties.

Steam Usage (for each header) [mass flow]

Any change in a systems process steam requirements would change steam usage requirements



Combustion Efficiency [%]:

Various improvements to the boiler can improve combustion efficiency

Fuel Type [fuel type]:

Fuel types may sometimes be switched for a variety of reasons

Blowdown Rate [%]:

Blowdown rates can often be reduced with better controls and water treatment, saving energy and water

Is the blowdown flashed? [yes/no]:

Steam systems may add blowdown flash tanks to improve waste energy and water recovery

Preheat Make-Up Water with Blowdown [yes/no]:

Blowdown water can also be used to preheat make-up water

Steam Temperature [temperature]:

Steam generation temperature may be changed by the adjusting boiler pressure or adding a superheating section

Deaerator Vent Rate[%]:

The deaerator vent rate may be reduced with better controls, reducing associated steam losses

Deaerator Pressure [pressure]:

Operating pressure may be adjusted to match condensate return pressure

The screenshot displays the 'Adjust Boiler Operation' section of a software interface. It contains several sub-sections, each with a checkbox and a table of parameters. The 'Adjust Steam Demand' checkbox is unchecked. The 'Adjust Boiler Operation' checkbox is checked. The sub-sections are:

- Change Boiler Combustion Efficiency:** Initial Boiler Combustion Efficiency: 85.0 %; NEW Combustion Efficiency*: 85.0 %
- Change Fuel Type:** Initial Fuel Type: Natural Gas; NEW Fuel Type*: Natural Gas
- Change Boiler Blowdown Rate:** Initial Boiler Blowdown Rate: 2.0 %; NEW Blowdown Rate*: 2.0 %
- Blowdown Flash to LP:** Flash Blowdown? Base: No; Adjusted*: No
- Preheat Make-Up Water with Blowdown:** Preheat Make-Up: No; NEW Preheat Make-Up*: No; Approach Temperature: 20.0 °F; NEW Approach Temperature*: 20 °F
- Change Steam Generation Conditions:** Initial Steam Temperature: 588.9 °F; NEW Steam Temperature*: °F
- Change DA Operating Conditions:** Initial DA Vent Rate: 0.1 %; NEW DA Vent Rate*: 0.1 %; Initial DA Pressure: 15.0 psig; NEW DA Pressure*: 15 psig

The adjustment to the Steam Turbine are the same as the base model. On/Off can be changed to add or remove a steam turbine:

Isentropic Efficiency [%]:

During turbine maintenance and overhauls isentropic efficiency can be changed inadvertently or intentionally

Generator Efficiency [%]:

Upgrading or repairing a generator can improve efficiency

Condenser Pressure [[vacuum pressure](#)] (condensing only):

Changes to cooling fluid flow/temperature affect pressure

Operation Type (switching types is an allowed adjustment)

Balance Header

Removes limits and fixed operation

Steam Flow [[mass flow](#)]:

Specifically set steam flow

Flow Range [[mass flow](#)]:

Flow might be allowed to change when it was previously fixed or unrestricted

Power Generation [[power](#)]:

Specifically set power generation

Power Range [[power](#)]:

Power generation might be allowed to change when it was previously fixed or unrestricted

The screenshot shows the 'Adjust Steam Turbine Operation' window with the following settings:

Adjust Steam Turbine Operation			
<input checked="" type="checkbox"/> Adjust Steam Turbine Operation			
<input checked="" type="checkbox"/> Modify HP to Condensing Steam Turbine			
Initial Turbine Status	Off	Adjusted Status*	<input type="checkbox"/> On/Off
<input checked="" type="checkbox"/> Modify HP to LP Steam Turbine			
Initial Turbine Status	On	Adjusted Status*	<input checked="" type="checkbox"/> On/Off
Isentropic Efficiency	65.0 %	Isentropic Efficiency*	65 %
Generation Efficiency	100.0 %	Generation Efficiency*	100 %
Operation	Balance Header	Operation*	Flow Range
		Minimum Flow*	50 ktb/hr
		Maximum Flow*	150 ktb/hr
<input checked="" type="checkbox"/> Modify HP to MP Steam Turbine			
Initial Turbine Status	On	Adjusted Status*	<input checked="" type="checkbox"/> On/Off
Isentropic Efficiency	65.0 %	Isentropic Efficiency*	65 %
Generation Efficiency	100.0 %	Generation Efficiency*	100 %
Operation	Balance Header	Operation*	Balance Header
<input checked="" type="checkbox"/> Modify MP to LP Steam Turbine			
Initial Turbine Status	Off	Adjusted Status*	<input type="checkbox"/> On/Off

Condensate adjustments include:

- **Condensate Return Rates [%]**
 - Improvements to the condensate return system can increase the return rate
- **Condensate Flash to Header (MP/LP) [yes/no]**
 - Flash tanks can be added that will flash high pressure condensate, saving energy and water
- **Condensate Return Temperature [temperature]**
 - Improvements to the condensate return system can increase the return temperature

The screenshot shows the 'Adjust Condensate Handling' configuration window. It is divided into four sections, each with a checked checkbox:

- Condensate Recovery:** A table with three rows. Each row has 'Initial' and 'NEW' columns for 'HP', 'MP', and 'LP' Condensate Return, with values of 50.0 % and 50.0 % respectively.
- Condensate Flash to MP:** A row with 'Flash Condensate to MP? Base:' set to 'No' and 'Adjusted*' set to 'No'.
- Condensate Flash to LP:** A row with 'Flash Condensate to LP? Base:' set to 'No' and 'Adjusted*' set to 'No'.
- Modify Condensate Return Temperature:** A row with 'Initial Condensate Return Temperature:' set to '150.0 °F' and 'NEW Condensate Return Temperature*' set to an empty field.

Insulation / Heat Loss adjustments include:

- **Heat Loss for each Header [%]**
 - Improvements in insulation will likely reduce a header's heat loss by a certain %, the heat loss % should similarly be adjusted to reflect this improvement

Example:

Initial Heat Loss: 0.10%

Potential Improvement of Insulation: 50%

NEW Heat Loss: 0.05%

Adjust Insulation / Heat Loss

Adjust Heat Loss Percentage

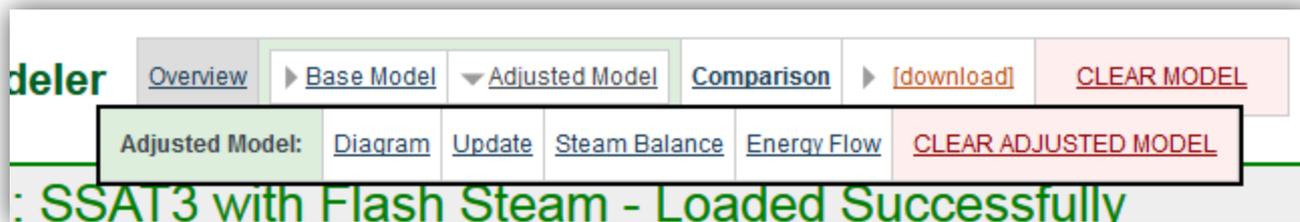
Initial HP Heat Loss	0.10 %	NEW Heat Loss*	<input type="text" value="0.05"/> %
Initial MP Heat Loss	0.10 %	NEW Heat Loss*	<input type="text" value="0.05"/> %
Initial LP Heat Loss	0.10 %	NEW Heat Loss*	<input type="text" value="0.05"/> %

The Adjusted Model can be reviewed in exactly the same way as the Base Model:

- View a **Diagram** of the Adjusted Model
- **Update** the Base Model by modifying the initial base model form
- View a **Steam Balance** of the Base Model
- View a Sankey diagram of the base model **Energy Flow**
- And create an Adjusted version of the base model

*See the "[Review the Base Model](#)" section for specific details on these

Moving the mouse over "Adjusted Model" will open the menu of viewing options



The model **Comparison** page provides a detailed breakdown of the total costs and relative operating conditions. The benefit of these collective adjustments can quickly be evaluated based on the difference between both.

[Green = savings | Red = loss]

Included Tables:

Cost Summary

power, fuel, water, and total cost

Utility Balance

fuel, water, and electricity use

Lists Active Projects/Adjustments

specifically lists the name of each adjustment

Base Model vs Adjusted Model

Cost Summary	Base Model	Adjusted Model	Reduction	
	\$'000s/yr	\$'000s/yr	\$'000s/yr	
Power Cost	\$ 2,000	\$ 2,265	265	13.3%
Fuel Cost	\$ 23,837	\$ 22,856	-981	-4.1%
Make-Up Water Cost	\$ 441	\$ 434	-6	-1.4%
Total Cost	\$ 26,277	\$ 25,555	-722	-2.7%

Utility Balance	Base	After Projects	Reduction		Units
Power Generation	13,807.6	13,144.3	-663.2	-4.8%	kW
Power Import	5,000.0	5,663.2	663.2	13.3%	kW
Total Site Demand	18,807.6	18,807.6	0.0	0.0%	kW
Boiler Fuel	515.5	494.3	-21.2	-4.1%	MMBtu/hr
Fuel Type	Natural Gas	Natural Gas			
CO ₂ Emissions*	218,818	209,815	-9,003	-4.1%	tons
Boiler Steam	410.2	393.3	-16.9	-4.1%	klb/hr
Make Up Water	367.2	361.9	-5.3	-1.4%	gpm

*Source of CO₂ Coefficients: <http://www.eia.gov/oiaf/1605/coefficients.html>

Adjusted Model: Active Projects

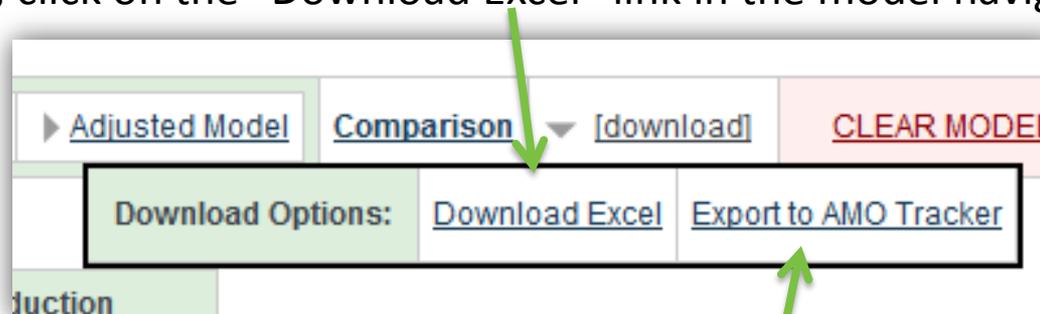
Adjust Boiler Operation
<ul style="list-style-type: none"> Blowdown Flash to LP
Adjust Condensate Handling
<ul style="list-style-type: none"> Condensate Flash to MP Condensate Flash to LP

WARNING:

- **STEAM MODELS ARE NOT SAVED ONLINE**
- **IF THE WEB BROWSER IS CLOSED, THE STEAM MODELS ARE CLEARED**

To save for future use, models must be downloaded. Once downloaded, they can easily be reloaded at anytime.

To download, click on the “Download Excel” link in the model navigation menu:

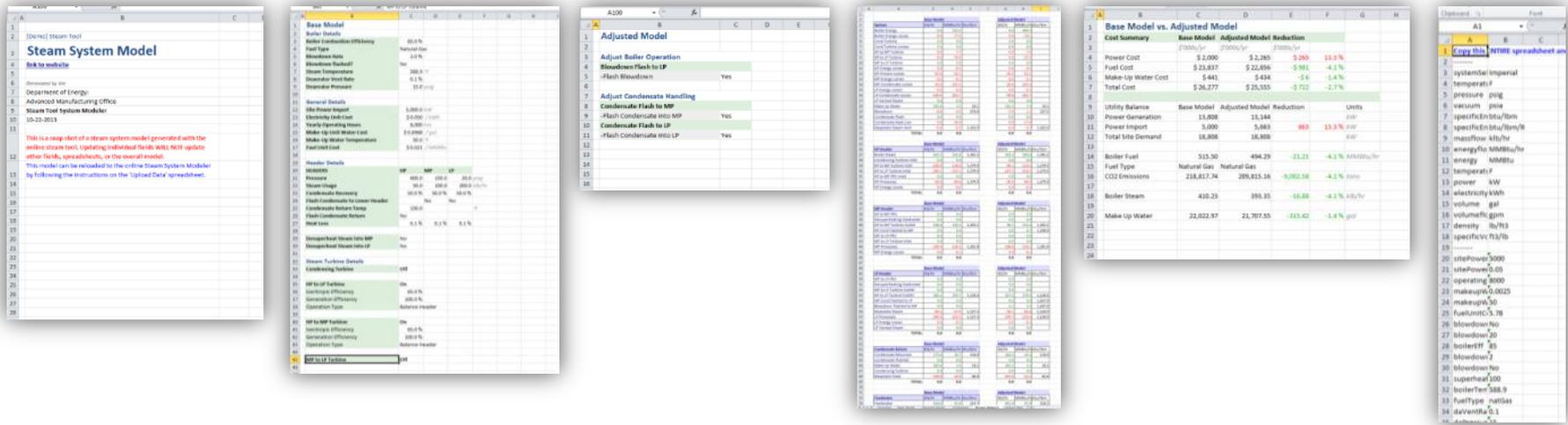


For reload instruction go to [Reloading Models](#)

Models can also be exported to the AMO Opportunity Tracker by clicking on the “Export to AMO Tracker” and following the instructions. **NOTE: The AMO Tracker file cannot be used to reload a model.**

The downloadable spreadsheet has 6 sheets, most of which mirror SSMT's online forms and reports :

- Title Page
- Base Model Details
- Adjusted Model Details
- Steam Balance
- Comparison of Models
- Upload Data – *used to reload model into SSMT*



To reload a Model, it must first have been downloaded as a spreadsheet.

To reload a model, copy the **ENTIRE** “Upload Data” spreadsheet and paste it into the steam tool reload/upload field on the “Reload Model” page.

There are 3 reload options:

- **Base and Adjusted Model** - reloads the model just as it was when it was downloaded
- **Base Model Only** - only reloads the base model
- **Load Adjusted Model as Base Model** - only reloads adjusted model as if it were the base model

The screenshot shows the 'Steam Calculators' interface. The main content area is titled 'Reload Steam System Model'. It includes a 'Select Reload Type:' dropdown menu set to 'Base and Adjusted Model'. Below this is a text input field with the instruction 'Copy the ENTIRE 'Upload Data' spreadsheet and paste it here:'. A 'Reload Model' button is positioned below the input field. A blue arrow points from this button to a spreadsheet window in the foreground, which displays a list of data columns and rows.

The export option is limited to English using imperial units.

Instructions for Export

- Generate downloadable file by hovering your mouse over “[download],” clicking “Export to AMO tracker,” and saving the file on your computer.
- Log on to the eCenter, go to the Project Opportunities Tracker, click “Import”, and choose the file that you just saved
- You will now be able to sort, edit, and save data from the Steam System modeler in the Project Opportunities Tracker

```
<?xml version="1.0" encoding="UTF-8"?>
- <Recommendations>
+ <Recommendation>
- <Recommendation>
+ <Recommendation>
- <Recommendation>
+ <Recommendation>
  <Plant_Action_ID/>
  <Action_ID/>
  <Action_Title>Adjust Condensate Handling</Action_Title>
  <Action_Description>Condensate Flash to LP (Savings based on individ
  <Action_Category>Steam Generation</Action_Category>
  <SourceToolID>10</SourceToolID>
  <Notes/>
  <StatusID/>
  <ProjectedCost/>
  <ProjectedSavings>91621.7</ProjectedSavings>
  <ProjectedROI/>
  <Implemented>False</Implemented>
  <ImplementationNotes/>
  <Priority/>
  <CustomCategory/>
  <Plant_ID/>
  <Deleted_Date/>
  <ProjectedCostSavings>500396</ProjectedCostSavings>
  <ProjectedCO2/>
  <SourceText/>
</Recommendation>
</Recommendations>
```

Number of Headers can be changed at any time

Base and adjusted models will automatically update.

Units can be changed at any time

Just go to preferences and change the units at any time. All models and calculations will automatically update.

Adjusted models can be set as a new base model

If modifications have been made an adjustment model can be set as a base model, allowing further adjustments to be modeled.

All Calculations and Models can be Reset and/or Cleared

To do this look for the reset and clear model links. Be careful as resets and clears are permanent.